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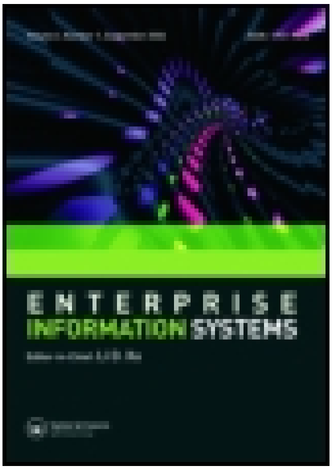

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Clustering-based urbanisation to improve enterprise information systems agility

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Clustering-based urbanisation to improve enterprise information systems agility

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Enterprises are daily facing pressures to demonstrate their ability to adapt quickly to the unpredictable changes of their dynamic in terms of technology, social, legislative, competitiveness and globalisation. Thus, to ensure its place in this hard context, enterprise must always be agile and must ensure its sustainability by a continuous improvement of its information system (IS). Therefore, the agility of enterprise information systems (EISs) can be considered today as a primary objective of any enterprise. One way of achieving this objective is by the urbanisation of the EIS in the context of continuous improvement to make it a real asset servicing enterprise strategy. This paper investigates the benefits of EISs urbanisation based on clustering techniques as a driver for agility production and/or improvement to help managers and IT management departments to improve continuously the performance of the enterprise and make appropriate decisions in the scope of the enterprise objectives and strategy. This approach is applied to the urbanisation of a tour operator EIS.

Keywords: enterprise information systems (EISs); IS urbanisation; enterprise architecture (EA); agility; continuous improvement; alignment, clustering

1. Introduction

Whatever its size, purpose or means, any organisation has an information system (IS) to support its internal operations and its interactions with the external environment. The IS is at the heart, if it is not the heart, of any business. It mirrors its image and the enterprise performance and sustainability depend on the effectiveness of its IS; hence, this later becomes a strategic tool. Change is permanent and random. It concerns the competitive environment, the role of the state and its administration, information and communication technologies (ICT), the concept of globalisation and business strategy. These later are behind the rapid and anarchic evolution of the enterprise information system (EIS) and are the reasons for which the enterprise strategy becomes less stable. Thus, enterprises are often required to reorganise and/or optimise their ISs in order to align them to the overall strategy to cope with the pressures of the external and/or internal environment pressures. However, it is difficult for enterprises to adapt easily to growing and random changes of the environments because information technologies evolve faster than the human capacity to be able to integrate them within companies. Some phase shifts between technology and ISs lead to massive failures: interlocking applications with the potential to strengthen the 'spaghetti' nature of the IS. It must be noted that enterprises are often faced with ISs characterised by an accumulation of heterogeneous applications, disparate technologies,

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data inconsistency, contradictory or redundant datum and a technical disorder over the years. Thus, there is no consistent system, since it is characterised by an organisation made of a disorderly increasing set of applications. With increasing entropy of ISs, the need for global coherence and integration becomes obvious (He and Xu 2014). IS strategic management was introduced during the 1980s to enable consistency between the processes, ISs and computer systems. This is the leitmotiv of Jean (2000) on urbanisation of business and ISs. He recommends the 'strategic alignment' which consists of making coherent the strategy, processes, ISs and computer systems. Traditionally, the term urbanisation refers to the planning and building of a city, but it has been used in recent years in the field of ISs (Longépé 2004). Urbanising an IS consists in federating its existing components around an overall architecture containing coherent blocks called zones, districts and islands, governed by principles and rules allowing more agility so that changes should be more easily controlled.

To cope with these pressures, controlling the EIS changes with the necessary reactivity and reducing costs, in order for the enterprise to ensure its existence, sustainability and security, are vital to manage its IS with rigour and consistency. This can be achieved by steering important and rapid changes at all levels of the EIS. The changes affect the IS technologies, applications, processes, organisation and human resources. All these components influence the enterprise strategy and vice versa. Thus, there must be enough agility in an IS to be aligned with the enterprise strategy. To make the EIS agile, it is imperative to urbanise it a priori to construct the enterprise architecture (EA). The objective of the urbanisation process is to simplify the vision of the EIS and to promote its use as a factor for value creation and source of innovation for the enterprise to ensure its evolution and competitiveness. And the objective of EA is to support the development and growth of an organisation while promoting balance between business innovation and IT efficiency; moreover, it helps in understanding the urbanisation evolution.

The aim of the present work is to propose an iterative strategic clustering-based approach to urbanise EIS in order to improve its agility characteristics: alignment, flexibility, proactivity, interoperability, adaptability, stability and effectiveness. These characteristics, when improved, will improve change management and maintain the global EIS consistent. Moreover, agile governance and best practices at all levels of the enterprise will contribute in EIS agility production. This will make easy the management of unpredictable changes while maintaining consistency of the EIS on a basis of a set of best practices, which make enterprise governance source of agility production. The concept of IS urbanisation has been used successfully on many projects; examples of projects are cited by Chaigneau (2004): (1) France Telecom: deletion of 695 databases in 4 years; (2) Renault: reduction from 5% to 10% of the cost of operating the accounting by removing applications; (3) Oresys: reduction from 10% to 20% of the cost of preliminary studies with maps; and (4) Gartner: reduction of 30% of maintenance costs.

This paper is organised as follows: Section 2 deals with the related work. Section 3 presents the concepts of urbanisation and EA. Section 4 presents the details of the proposed approach. Section 5 deals with the case study, which consists of urbanisation of a tour operator EIS and a comparison with the results obtained by Longépé's urbanisation methodology (Longépé 2004).

2. Related work

Regarding urbanisation and EA approaches, several approaches dealing with the urbanisation and architecting issues of ISs have been proposed. Some of them are based on the

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systemic vision of the IS which addresses the IS, first as a monolithic block, then broken down into levels of abstraction by applying appropriate transition rules to get the corresponding representation in the next level of abstraction, and is mainly based on the IS invariants. Other frameworks consider the IS aspects in different manners. For instance

- Zachman (1987) defined an EA framework whose vision was that enterprise value and agility could best be realised in a holistic approach to systems architecture that explicitly looks at every important issue from every important perspective.
- The Open Group (2011) proposed a framework named TOGAF (The Open Group Architecture Framework) which divides an EA into four categories: (1) Business architecture: describes the processes the business uses to meet its goals; (2) Application architecture: describes how specific applications are designed and how they interact with each other; (3) Data architecture: describes how the enterprise datastores are organised and accessed; and (4) Technical architecture: describes the hardware and software infrastructure that supports applications and their interactions.
- Enterprise architecture, in the Gartner view, is about strategy, not about engineering. It is focused on the destination. The two things that are most important to Gartner are *where an organisation is going* and *how it will get there*. Any architectural activity that is extraneous to these questions is irrelevant (Bittler and Kreizman 2005; James et al. 2005).
- Federal enterprise architecture (FEA) can be viewed as either a methodology for creating enterprise architectures or the result of applying that process to a particular enterprise. The FEA perspective on EA is that an enterprise is built of *segments*, an idea first introduced by FEAF (CIOC 2001). A segment is a major line-of-business functionality, such as human resources. There are two types of segments: *core mission-area segments* and *business-services segments* (FEAPMO 2006).

These above frameworks have been compared by Sessions (2007) by applying 11criteria that are rated in the range [1, 4], and it was concluded that none of these EA methodologies is really complete; each has its advantages and disadvantages. The proposed approach, in the present work, is not in contradiction with the above ones, it is rather a continuation or synthesis since it includes their advantages in such a way that it covers all the aspects of the EIS that is segmented into its dimensions, which are architected individually in the context of the EIS to take into account the mutual negative and positive influences.

Moreover, the following approaches are proposed to urbanise ISs:

Sassoon (1998), the precursor of the concept of urbanisation, suggested a rule-based approach and not a process consisting of phases and nothing is said about agility, whereas the present work proposes an approach based on an iterative life cycle which takes into account Sassoon's rules and manages continuously the IS with respect to the enterprise strategy and the dynamic of the contingency variables in the context of EIS agility.

Jean (2000) introduced the idea of strategic invariants in his phased life cycle. However, it is sequential, there is no updating phase of strategic invariants and urbanisation plan and there is no validation phase. The present work addresses the drawbacks of the

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approach of Jean and continuously ensures the IS maintenance and evolution in the context of internal and external changes in order to improve its agility.

Chelli (2003) proposed an approach based on the establishment of agility indicators and of non-agile IS components; there is no strategic invariants identification and no updating phase. This approach, even based on the agility indicators, does not ensure the agility preservation because its life cycle is sequential, whereas the proposed approach in this present work takes into account the enterprise strategic objectives, agility improvement and preservation.

Cigref members (Cigref 2003) suggested an approach based on the combination of top-down decomposition and bottom-up composition of the IS by defining the strategic invariants and viewing the plan in the form of a dashboard. However, the phases of this approach are not explicit and there is no updating phase. This approach is systemic and validation of the decomposition is taken into account by the combination of the descending and ascending visions. However, its application for complex EISs will not be an easy task. The present work takes into account the growing complexity of nowadays EISs and suggests addressing each of its dimensions individually and their interactions in the context of the whole system and of agility production/consumption and/or improvement.

Finally, Longépé (2004) proposed an evolutionary approach with the possibility of updating the strategy and regular maintenance target and the convergence. However, without showing how to go back to the previous phases because the life cycle is sequential; the implementation phase of the urbanisation plan is ignored, there is no validation phase and there is no configuration management phase. The present work proposes a complete approach which completes the approach of Longépé. Moreover, it breaks down the EIS into five main parts with respect to the proposed conceptualisation to master the complexity of the actual EIS, and then it applies the urbanisation decomposition rules to generate an urbanisation map for each dimension by ensuring the correlation between the dimensions and improving their agility to make the whole EIS more agile.

Regarding their age and the rapid evolution of EISs with the environments evolution, this research work suggests an updated approach which combines the advantages of the existing ones while minimising their disadvantages, takes into account nowadays EIS specificities and complexity, both in terms of internal and external environments characteristics. Mainly, it includes the environmental dimension urbanisation which is not considered in the existing approaches. In addition, it is based on clustering techniques and continuous improvement in the scope of improving EIS agility and helps managers to make better decisions rapidly. This allows for traceability of the EIS and ensures its evolution, interoperability and flexibility, thus its agility. Moreover, it facilitates (1) requirements modelling and change impact determination (Niu, Xu, and Bi 2013a), (2) architecture analysis and evaluation (Niu et al. 2013b) and (3) integration problem assessment (He and Xu 2014; Fang et al. 2014).

Let us note that herein approach, by urbanising the environment dimension, makes possible (1) improvement of the collaboration and proximity between partners and customers; (2) clustering of customers and providers in terms of their nature, services level and growth potential; and (3) clustering of partners in terms of their types: target, opportunities, strategy and status quo. This can help managers and IT managers to anticipate their interactions with the external actors.

3. Urbanising and architecting EIS

Enterprise architectures (EAs) address the same issues as IS urbanisation. They deal with all issues related to engineering projects, processes, rules and objectives. EA is a top-down approach based on a global modelling of all enterprise resources (actors, processes, applications, technical architectures), which are segmented according to the following necessary visions: strategic vision, business vision, architect vision and developer vision. Indeed, there are two major schools which converge despite their differences in terms of used concepts: (1) the French school, which is represented by the work of Sassoon (1998), Jean (2000), Chelli (2003), Cigref (2003) and Longépé (2004), which deals with the urbanisation of ISs and (2) the Anglosaxon school, represented by Zachman (1987), TOGAF (Open Group 2011), Gartner (James et al. 2005) and FEAPMO (2006) frameworks, which advocate the concept of EA. Due to the increase of their complexity and distribution, ISs are compared to urban systems or cities because of the need for their urbanisation or architecting in order to improve their efficiency and performance by exploiting the full potential of the EIS (Xu 2011). The main triggers of urbanisation are organisational changes, the IT market evolution, technological developments, interoperability enhancement, integration, evolutivity and globalisation. Hence, urbanisation makes an IS best suited to serve the enterprise strategy and anticipate changes in the business environment. Managers of ISs of enterprises have experienced hard times, with the year 2000 or the introduction of the European money, and are now facing the requirements of a febrile and demanding economy. They wish to satisfy the demand of technological solutions, but they face several problems, e. g. budget or applications assets (often poorly known), which make the integration of new projects risky. Managing these problems leads to dramatic failures. To cope with these failures, enterprises first look for reliable ISs, then look for open ISs while maintaining them at a high level of security. The enterprise blueprint, which is a strategic plan used to drive the IT development in the enterprise by translating its strategy into actions related to the IS (Vidal, Mangholz, and Vital-Durand 2007), has widely met these expectations. Nowadays, agility is being added to these two required historical characteristics. While it was an advantage for enterprises in a stable economic environment, today economic instability makes agility an even essential quality (Cigref 2003; Custodio, Thorogood, and Yetton 2007). So, IS agility becomes one of the main objectives of all IS departments and must be a quality of any enterprise in order to cope with the customers' demand to face competition and rapid technology changes (Desouza 2007; Goranson 1999; Rouse 2007). Indeed, the enterprise blueprint does not address this issue, but it is supplanted by the concept of EIS urbanisation (Club-urba-ea 2006; Club-urba-si 2003) and the concepts of EA and integration (Niu, Xu, and Bi 2013a; Xu 2011; He and Xu 2014; Fang et al. 2014).

ISs have several dimensions which can be analysed with the typologies of the enterprises and a complexity reflecting the human organisation they must serve. Urbanisation is necessary for two reasons: (1) to maintain and manage, at best, a capital until its effective obsolescence and (2) to have agile IS able to evolve quickly and efficiently, according to the changing needs (Leroux 2004; Longépé 2004; Sassoon 1998).

To reach these objectives, first, one has to define what should be the target IS, i.e. the one which will best serve the enterprise strategy and satisfy the business processes, in short an aligned IS (Cigref 2003, 2002b). Second, one has to set the construction rules allowing the system to avoid repeating errors made in the former IS and to anticipate

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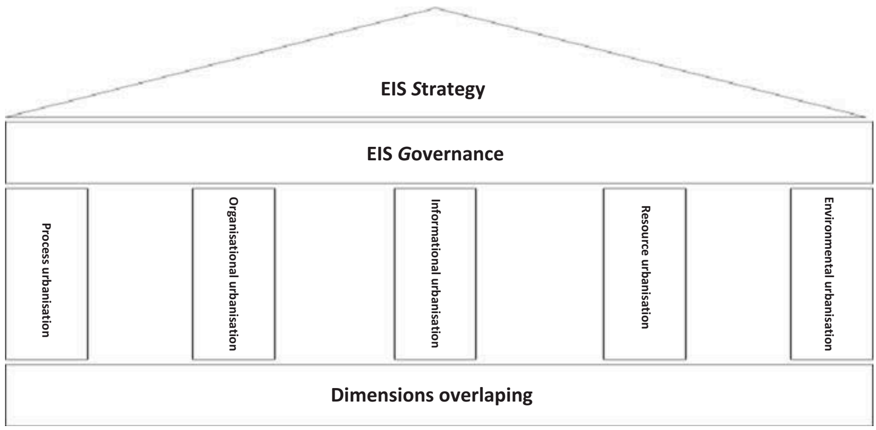

Figure 1. EIS urbanisation framework.

changes, in short an agile IS (Galliers 2007). Finally, one has to determine the path to follow from the actual IS to get to the new one. This requires good knowledge of the old IS in order to set appropriate criteria to know when to start and when to finish.

Urbanisation allows for obtaining predictable ISs for which their evolution with agility can be considered. It must combine three problematic sets to reach rules and a path of urbanisation: the management of the processing, the necessary security requirement and the expected optimisation. According to Leroux (2004) and Longépé (2004), the process of urbanisation is based on three main phases: (1) identification of the business strategy which determines the need, (2) definition of the functional and specific requirements maps and (3) identification of the technology needs. As depicted in Figure 1, inspired from (Cigref 2002a), urbanisation is a basis to reach alignment at different levels of each dimension of the EIS. First, urbanisation is realised for each dimension of the EIS, taking into account their interactions and their overlapping. Then, the process of alignment will be executed accordingly with respect to the governance directives, which are defined from the enterprise strategy. Hence, the process of urbanisation is first top-down (strategy analysis and design) then bottom-up (execution and validation). This will increase the flexibility, the response capabilities and the efficiency of the EIS, hence its agility.

4. Clustering-based EIS urbanisation

It is essential to consider the organisation as a whole to ensure global integration. Hence, according to the complexity of the EISs, the present work suggests to use the POIRE conceptualisation (Imache, Izza, and Ahmed-Nacer 2012), which consists of five interrelated and complementary dimensions (Figure 2) that will be considered individually and collectively to ensure global consistency and visibility.

This conceptualisation of the EIS takes into account all the internal and external aspects of the enterprise and ensures completeness and coherence of its IS analysis and audit. Notice that each dimension has interactions with all the other ones, directly or indirectly. The influence of any dimension depends on its weight for a given EIS, the context of evolution and the enterprise strategy. Moreover, applying Sassoon's rules (Sassoon 1998) when clustering the EIS dimensions eliminates the undesired influences and superfluous interactions; this will yield, at each level of abstraction, in high cohesion

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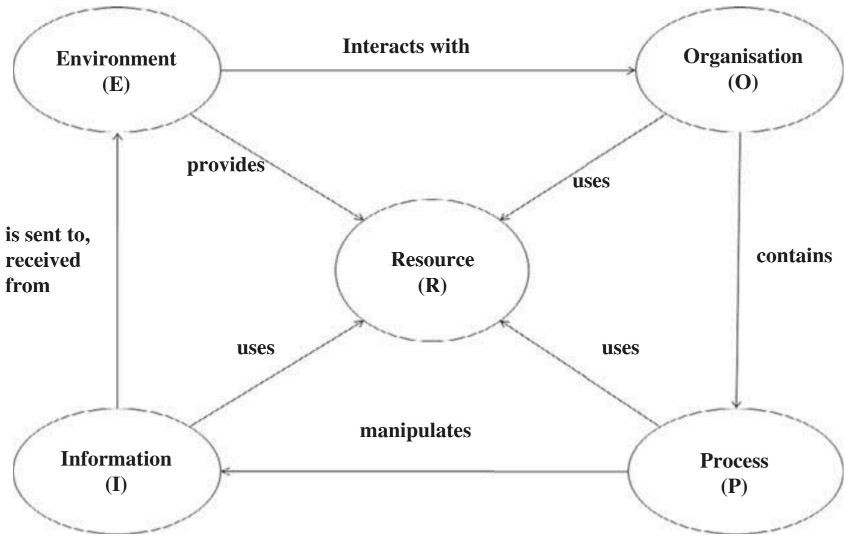

Figure 2. EIS dimensions and their interactions.

clusters with a weak coupling between them. Moreover, any improvement in one dimension leads to a favourable development of the other ones.

According to the EIS conceptualisation suggested herein, the urbanisation process is made of two subsequent phases: (1) a partitioning clustering technique to identify the five dimensions and (2) a bottom-up hierarchical clustering technique (Arabie, Hubert, and De Soete 1996) for each dimension. The later is used to urbanise the IS in a way to form different clusters, i.e. zones made of districts and in which each district is made of islands (Figure 3). This ensures global consistency and dimensions correlation. The clustering techniques are based on the cluster similarity analysis, weak coupling and high cohesion characteristics. This will result in a better visibility of the IS, and hence it will improve its agility and controllability at the level of each dimension. As a result, the agility of the EIS will be controllable and improved.

The urbanisation process leads to a better structuring of the EIS architecture. It structures, in an elegant manner, the EIS dimensions in a way that makes them visible and can cope with unpredictable changes. The urbanisation approach includes

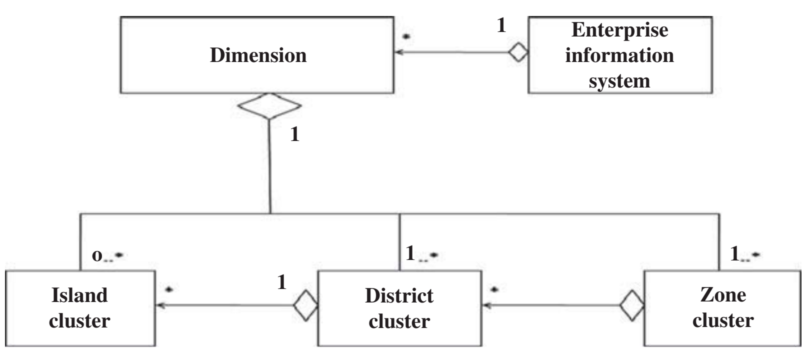

Figure 3. EIS clustering meta-model (using UML notation).

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- Process dimension urbanisation: it is used to identify the stable and coherent process clusters in a given context, their subsidiarity in the organisation and invoked resources, which allows for rapid change implementation, ensures process maintenance and continuous improvement; hence, it addresses the need for process agility.
- Organisational dimension urbanisation: it is used to identify coherent organisational clusters having similar characteristics, such as competency requirements, related processes, goals and invoked data. This yields in rapid organisational structure reconfiguration in order to deal with changes, if any; hence, it addresses the need for organisational agility.
- Information dimension urbanisation: it is used to classify the different types of information into appropriate clusters according to their characteristics, such as completeness, coherence, criticality, freshness, subsidiarity in the organisation, management processes and importance in the IS. This makes possible to define adequate access rules and to ensure their preservation, consistency, transparency of fluid communication at all levels of the enterprise and with external actors since information sharing is vital. Moreover, it makes easy its enrichment and updating; hence, it addresses the need for informational agility.
- Resource dimension urbanisation: it is used to show the clusters of resources, subsidiarity and availability to facilitate their management, governance and make rapid allocation and/or reallocation when necessary in terms of polyvalence and adaptation levels; hence, it addresses the need for resource agility.
- Environment dimension urbanisation: it is used to show the front office interacting with the external environment that influence, directly or indirectly, the enterprise strategy in a given context. This makes possible to analyse and evaluate rapidly the external change influences to help managers and IT specialists anticipating the interactions with the external environment; hence, it addresses the need for environment agility.

Moreover, EIS urbanisation makes possible to define the boundaries of each dimension and the dimension overlaps. This is used to make visible the influence of any change in any dimension over the other ones and allows driving easily the related management issues.

4.1. Dimension clustering techniques

Once the EIS has been partitioned into the proposed dimension conceptualisation, the bottom-up clustering technique is applied for each dimension taking into account its characteristics. This is done on the basis of best practices (Longépé 2004) and the applicable urbanisation rules selected for the dimension of the considered EIS, from Sassoon's rules (1998): (1) Membership: a district can only belong to one zone, and an island can belong to only one district; (2) Autonomy: a cluster is independent of other clusters; (3) Asynchrony: a cluster can process an event without waiting for any result from another cluster; (4) Interface: a cluster requires only two interfaces, an input interface and an output interface; (5) Ownership of data: a cluster has its own data and processes, and any cluster can view data from another cluster; (6) Normalisation of exchanges: the formats of exchanges between the different clusters or actors of the IS are standardised; and finally (7) Workflow management: all communications between clusters are done through the system flow management.

The bottom-up clustering approach results first in the identification of island clusters, upon the application of similarity characteristics on the objects of the dimension, once the islands clusters, if any, are obtained. They are aggregated by applying similarity characteristics in order to generate island clusters, which are then aggregated at their turn by applying similarity characteristics in order to generate island clusters.

To evaluate the similarity or dissimilarity between clusters, different strategies are possible (Arabie, Hubert, and De Soete 1996):

- Minimum link: the dissimilarity D between two clusters A and B is given by Equation (1):

$$\mathrm{D}(\mathrm{A},\mathrm{B}) = \min[d(x,y)/x \in \mathrm{A}\,\text{and}\,\mathrm{y} \in \mathrm{B}] \tag{1}$$

  However, the aggregation obtained by this strategy may result in the aggregation of heterogeneous clusters.

- Complete link: the dissimilarity D between two clusters A and B is the highest dissimilarity between an object x of A and an object y of B and is given by Equation (2):

$$\mathrm{D}(\mathrm{A},\mathrm{B}) = \max[d(x,y)/x \in \mathrm{A}\ \text{and}\, y \in \mathrm{B}] \tag{2}$$

  The aggregation obtained by this strategy generates compact clusters.

- Medium link: the dissimilarity between two clusters A and B is the average of the dissimilarities between objects x_i of A and objects y_j of B and is given by Equation (3):

$$\mathrm{D}(\mathrm{A},\mathrm{B}) = \frac{\sum_{i=1}^{n_x}\sum_{j=1}^{n_y} d\left(x_i, y_j\right)}{n_x n_y} \tag{3}$$

This aggregation strategy is a good compromise between the two preceding strategies. It has two variants: (1) proportional link: the mean dissimilarity between objects of A and objects of B is calculated as a sum of weighted dissimilarities, such that an equal weight is attributed to the two clusters and (2) flexible link: this link uses a parameter ß Є [–1, +1], which is used to generate aggregation criteria. If *ß* = 0, then the proportional link is obtained, if ß converges towards 1, then a complete link is obtained and if it converges towards –1, a flexible link is obtained.

Moreover, Ward (1963) defined an aggregation criterion which results in homogeneous components of clusters. However, this criterion applies only for quadratic distances. In this case, if n_x and n_y designate, respectively, the number of objects in a given cluster and m is the cluster mass, this criterion is calculated using Equation (4):

$$\mathrm{D}(\mathrm{A},\mathrm{B}) = \frac{n_x n_y}{n_x + n_y}\|m_{\mathrm{A}} - m_{\mathrm{B}}\|^2 \tag{4}$$

In the present work, the Ward criterion is used, which seems to be the most appropriate clustering technique because it ensures inertia inside clusters and between them. At each level of abstraction of each EIS dimension, in a bottom-up approach, after identifying the

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elementary objects of a dimension, the clustering semi-automatic process is applied and is divided into two main phases:

- Phase 1: Calculate the similarity matrix $\delta(z_i, z_j)$ between objects or clusters. Each element of the matrix is calculated as the weighted sum of the affinity cohesion and coupling parameters: logical (l), temporal (t), communicational (c), sequential (s), functional (f), message (m), data (d), common (co) and control (ct). These affinity parameters are set by the user in the range [0, 1] and they are specific for each dimension of the EIS.

For example, the affinity parameters of the tour operator process dimension that are retained in the context of the present work are logical (l), temporal (t), communicational (c), sequential (s) and functional (f).The elements of the similarity matrix are given by Equation (5):

$$\delta(z_i, z_j) = \sum_{x \in \{l,t,c,s,f\}} \mathrm{W}_x \, \delta x(z_i, z_j) \tag{5}$$

with the weight $\mathrm{W}_x \in [0, 1]$, and $\sum \mathrm{W}_x = 1$.

Let us note that if $\delta(z_i, z_j)$ converges towards 1 then there is a high similarity between the clusters z_i and z_j, and if it converges towards 0 then there is a high dissimilarity between z_i and z_j.

- Phase 2: Determine the clusters. The Ward criterion is applied to the similarity matrix obtained in the first phase to aggregate the objects or clusters. The result of this iteration is the input of the next iteration.

This ascending hierarchical clustering process is illustrated by the following generic algorithm:

```
Clustering algorithm
  Input:
    Dimension objects
    Affinity parameters
  Output:
     Clusters trees
  Method:
   I = 0 //I represents the level of abstraction //
   Do
    Initialisation
    Calculate the similarity matrix
    Calculate the Ward distance D between objects or clusters
   While (number of objects or clusters >1)
     Group the two near objects or clusters according to D
    Calculate D between the obtained group and the remaining ones
   Endofwhile
   I = I +1
  While (I < 3)
  End_of_clustering_algorithm
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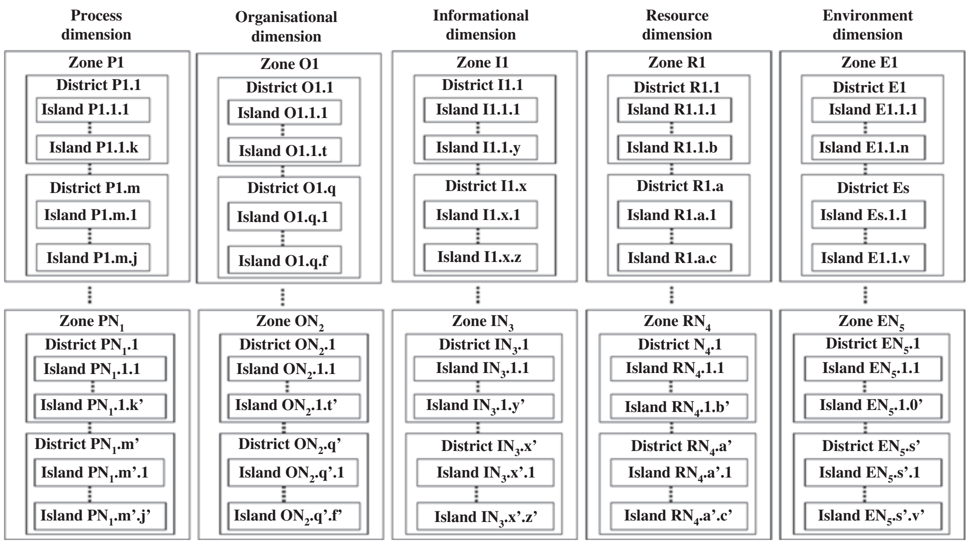

Figure 4. POIRE EIS topography.

When applying this generic clustering algorithm for each EIS dimension according to the proposed conceptualisation, it will generate a topography or a Ground Occupation Plan (GOP) of the whole EIS (Figure 4).

For a given EIS, after horizontal partitioning into five dimensions, the Ward criterion is applied for each dimension to be clustered, in a bottom-up approach, in the scope of EIS governance and strategy, into its corresponding clusters: islands, if any, districts and zones. First, the collected changes are analysed to study their influence and consequence on the actual enterprise strategy (Nan Niu et al. 2013a), define the strategic objectives and justify, if any, the investment. Second, the study planning phase consists of gathering the success conditions, defining the study cycle, rules, procedures, resources management, tasks planning and allocation and quality assurance formalisation. Third, the actual system analysis phase consists of mapping the actual system and establishes the diagnosis in terms of agility at different levels of the EIS. This is done by auditing the EIS. Fourth, once the actual system has been analysed, the target strategy definition phase starts and consists of defining the strategic invariants of each dimension of the EIS and associating a key performance indicator to each strategic objective. Fifth, the phase of urbanisation plan deals with the establishment of the GOP by partitioning the EIS into five dimensions and clustering each of them as indicated in Figure 4 by applying the clustering algorithm. The result will be illustrated as in Figure 5, and a target structure of the EIS is defined. An urbanisation map is the basic tool for any evolutionary maintenance (Minganson 2000). The GOP sets the exploitation rules of the IS space. It defines the break down of the EIS dimensions into management clusters (zones, districts and islands) and specifies the services and responsibilities attached to each cluster with respect to the urbanisation rules, such as high cohesion, weak coupling abstraction, interfaces, identifying dimension overlapping to manage any change or modification in terms of impact analysis and influences between dimensions, coordination and integration in the context of the EIS global coherence (Niu et al. 2013b). Sixth, the migration plan phase defines how to go from the actual system to the target one and at which rate and determines the starting points of the migration. Seventh, the implementation phase starts with respect to the

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Process P_i	Logical (l)	Communicational (c)	Sequential (s)	Functional (f)
P_1	l_1, l_2	c_3, c_4	s_1, s_2	f_1
P_2	l_1, l_3	c_2, c_4	s_2, s_3	f_1
P_3	l_3, l_4	c_5	s_3, s_4	f_1
P_4	l_4, l_5	c_6	s_4, s_5	f_2
P_5	l_5, l_6, l_7	c_1	s_5, s_6, s_7	f_2

	P_1	P_2	P_3	P_4	P_5
P_1	1.0000	0.5124	0.2500	0.0000	0.0000
P_2	0.5124	1.0000	0.6251	0.0000	0.0000
P_3	0.2500	0.6251	1.0000	0.3751	0.0000
P_4	0.0000	0.0000	0.3751	1.0000	0.4771
P_5	0.0000	0.0000	0.0000	0.4771	1.0000

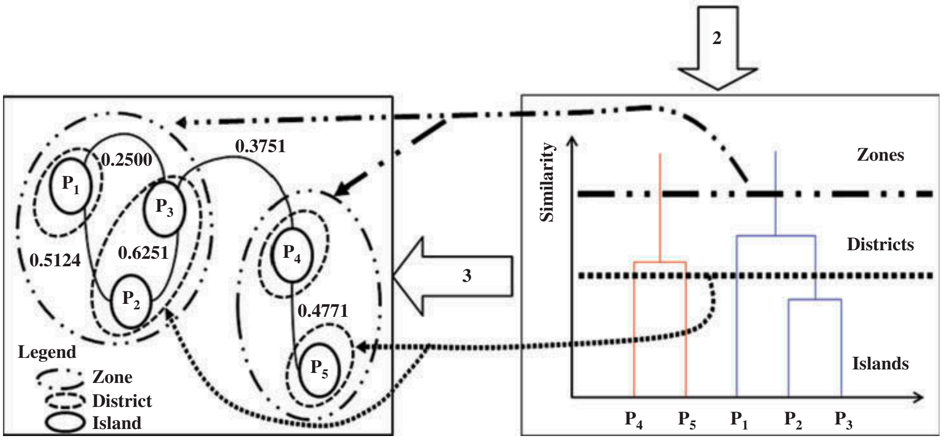

Figure 5. Process dimension clustering.

prescriptions defined in the previous phase. Moreover, the maintenance process starts with the implementation in order to take into account any internal and external changes. Eighth, the phase of configuration management starts and consists of keeping the traceability of the EIS and of the evaluation procedures. Moreover, to guarantee the evolution and adaptability of the EIS to eventual internal and/or external changes, continuous improvement is recommended.

Let us illustrate the application of the semi-automatic algorithm to the tour operator EIS process dimension clustering by considering five processes with specific characteristics and execute the clustering algorithm.

Once the process dimension objects has been identified, the user sets the affinity parameters and then the similarity matrix is calculated. The weights that are used to calculate the similarity matrix are set to $w_l = w_c = w_s = w_f = 0.25$ and $w_t = 0$.

Once the similarity matrix has been calculated using the dedicated function of the clustering algorithm, it is injected to the second phase, which exploits the XLSTAT software (Addinsoft 2011) to produce a dendrogram. The latter is interpreted to define process dimension clusters (Figure 5).

The determination of process clusters is based on fixing a troncature line on the obtained dendrogram. As shown in Figure 5, the first truncation line (first dotted line ··········) defines the limit between the process islands and districts clusters, whereas the second truncation line (second dotted line — ·· —), which is above the first truncation line, defines the limit between the process districts and zone clusters. It must be mentioned that the fixation of the truncation lines in this approach is subjective because it is still the result of human interpretation.

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5. Case study

5.1. Case study description

The case study deals with the urbanisation of a tour operator enterprise, which offers to its clients several types of trips throughout the world. There are three types of destinations: sea, mountains and cities. For each destination, there are three types of accommodations: hotels, bungalows or residences. All the trips offer many activities such as swimming, diving, tennis, golf, sailing, water skiing, climbing, cycling and so on. The enterprise is made of five departments: financial, marketing, commercial, exploitation and organisation. All these departments depend on the general direction of the enterprise. Travel agencies, which are located through several countries, depend on the commercial department. Moreover, the enterprise has collaborating agencies. The role of an agency is to help customers in choosing the appropriate travel upon several parameters, such as country, season, destination, accommodation, activities, prices and so on. The operation of the enterprise depends on the efficiency of its network and of its employees, its degree of competitiveness and the general regulations. The enterprise faces an irregular competitiveness; this yields in a decrease of gains. Moreover, by trying and making changes to cope with this situation, managers and engineers of the enterprise had to face the '"spaghetti" architecture' or chaotic nature of the EIS. This is due to the lack of structuring of the IS, the lack of management configuration and the lack of urbanisation of the IS. Hence, managers of the enterprise wish to implement a new strategy for their company to be leader in its activities. For this reason, it is suggested to urbanise the EIS. The objective of the urbanisation of the IS of the tour operator is to make an easy and rapid alignment of the IS architecture to the enterprise strategy, to make easy a progressive evolution and enterprise integration by ensuring a continuity of service and reduce dimensional coupling while increasing cohesion of each dimension of the EIS. This will improve the agility of the EIS.

- First, the five suggested dimensions of the tour operator EIS have been identified. This has been done through the IS analysis and audit. Second, by interviewing managers and users, a description of each dimension is established by collecting its content, inputs and outputs, if any.
- Then, taking into account the mutual effects between the dimensions and applying Sassoon's rules for each dimension, the corresponding dimension urbanisation map made of zone clusters has been obtained. They are made of district clusters and the later are made of island clusters.

Longépé (2004) applied his IS urbanisation approach to a tour operator according to the framework shown in Figure 6 (Gartner 2002). This framework describes the IS in terms of layers from the high abstraction level (process perspective) to the lower abstraction level (applicative perspective) that are obtained successively, each one from the projection of the previous layer, following the systemic approach.

Each layer is made of three levels of urbanisation clusters: zones, districts and islands. So, for a complex IS, it will not be easy to master the complexity. It must be noted also that this way of dividing the IS does not take into account all the aspects of the EIS. Whereas, the proposed GOP model based on the suggested conceptualisation and clustering techniques results in the EIS architecture and makes easy its horizontal and vertical analysis.

The results of these break downs are summarised in Table 1 in a comparative way.

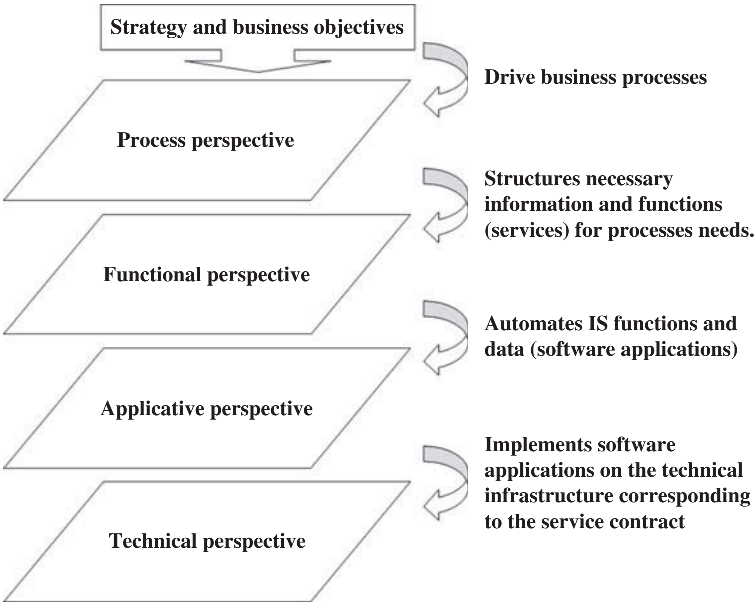

Figure 6. IS framework (Gartner 2002).

Table 1. Results.

	Longépé's results				POIRE results					
	Process level	Functional level	Applicative level	T	P	O	I	R	E	T
Zones	9	6	8	8	4	2	4	1	1	12
Districts	26	23	27	27	14	8	10	3	2	37
Islands	23	23	23	23	20	9	12	5	4	49

Note: P: Process, O: Organisational, I: Informational, R: Resource, E: Environment, T: Total.

5.2. Discussion and comparison with the results obtained in Longépé's case study

The choice of comparing the obtained results to those of Longépé is motivated by the fact treating the same application field: urbanisation of a tour operator IS. From the decomposition process point of view, two differences are noted: (1) Longépé considers the IS as a monolithic system which is then broken down, using a top-down approach, into levels of abstraction: process, functional, applicative and technical levels. Let us note that the technical level is not considered in his case study, and there is a high coupling between the abstraction levels. The next mapping is obtained by translating and refining the actual one into its corresponding mapping in the next immediate low level of abstraction until reaching the applicative level, which is ready to be implemented. The final map is made of eight zone clusters, twenty seven district clusters and twenty three island clusters. The proposed POIRE approach reduces the complexity of the EIS by the horizontal partitioning into five dimensions and then applies the proposed clustering algorithm, given in Section 4.1, for each IS dimension and Sassoon's rules to break down each dimension into hierarchical clusters (islands, districts and zones), meanwhile, maintaining the overall coherence of the EIS by taking into account the dimensions necessary for

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coupling. As a result, five maps are produced according to the proposed conceptualisation. Table 1 summarises the number of clusters, obtained at each level of abstraction, obtained for each dimension. According to these results, it is easy to note the difference in visibility of clusters; that is, the POIRE approach results in more atomicity and visibility than the approach of Longépé.

In addition to the map break down or clustering, five main criteria are considered: (1) Duration: the duration of the urbanisation process is set during the planning phase. Longépé suggested 19 weeks without the implementation phase. Whereas in the proposed approach, all the development phases are taken into consideration and the total duration is around 30 weeks: 19 weeks for the theoretical study and 11 weeks for the implementation, validation, configuration management and evaluation. (2) Life cycle: the life cycle to be applied is defined during the planning phase. It is noticed that the approach of Longépé is sequential, whereas the proposed life cycle is iterative; hence, it ensures coherence and completeness. (3) Operational process modelling: actual operational process modelling is done during the system analysis phase while mapping the actual business processes. Longépé limited the modelling refinement to five and then to three processes that are judged to have a large contribution in achieving the strategic objectives of the tour operator enterprise. The proposed approach starts with seven, then five and then three processes that are judged to be more important to reach the EIS strategic objectives. Let us note that the POIRE approach has three levels of refinement, which yields in a better understanding of IS. (4) Target architecture validation: the target architecture design is made during the phase of definition of the urbanisation plan, which results in the GOP. Longépé proceeds sequentially for the architectures design by level of abstraction of the IS: business, functional, applicative then technical. Validation is done sequentially in the order of design. Whereas, in the present case, five architectures are produced iteratively, one for each IS dimension simultaneously and validation is carried out in parallel, which makes easy to take into consideration the mutual effects between the IS dimensions. This ensures coherence and completeness. (5) Migration plan and updating phase: Longépé suggested a monitoring section whose role is updating; whereas in the POIRE approach, the migration and updating phase is ensured by an urbanism unit in collaboration with the monitoring section, which directly depends on the corporate direction.

6. Conclusion

Change is not a punctual phase, but a permanent state. Therefore, an EIS must have, continuously, a necessary degree of agility to be aligned with the enterprise strategy according to the influence of internal and/or external contingency variables. To address the problem of agility of EISs to face changes and respond quickly, it is necessary to structure the EIS as a city of information, effective and efficient structure. The concept of urbanisation appeared at the time it becomes totally unrealistic to rebuild an entire IS, by making a clean sweep of the existing capital, but on the contrary, reorganisation and maintenance activities are permanent as in city. In the authors' opinion, it is not sufficient to urbanise an EIS for a given context or situation, but it is important to maintain it permanently urbanised. Hence, there is a need for a continuous improvement of the EIS to maintain its urbanisation level. This will yield in a continuous agility improvement and/or production. To reach these objectives, enterprise managers must install an eve mission whose role is to anticipate changes and define a revealing or efficient global scoreboard in the scope of the EIS governance framework which is based on the enterprise strategy. Moreover, the adequateness and quality of perception,

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actions, decisions and the response time represent a basis for achieving goals according to the enterprise strategy in a given context.

Urbanisation promotes the EIS visibility and integration. It shows the dimensions overlapping, which makes easy (1) the detection and analysis of the impact of any change in any dimension over the other ones during the process of alignment of the EIS to the enterprise strategy, (2) the configuration management and (3) the traceability of the EIS evolution. Moreover, a human aspect, which is the change actor and the destination of changes are, in the authors' opinion, a key point to be addressed in urbanisation and agility issues within modern enterprises to improve permanently the EIS agility. The present work proposed an iterative urbanisation approach which takes into account nowadays EIS specificities, complexity internal and external environments characteristics. It is based on (1) the POIRE conceptualisation, which promotes internal and external visibility and consistency of the EIS, (2) a semi-automatic clustering technique which results in homogeneous, coherent and weak coupled clusters; minimises information silos and optimises core processes; hence, makes easy intra- and inter-cluster integration, service oriented architecture (SOA) implementation, enterprise application integration (EAI) and business logic integration (He and Xu 2014). This constitutes a major point of the EA construction and reconfiguration depending on the context. And (3) it is based on continuous improvement in the scope of improving EIS agility and helps managers to make better decisions proactively or rapidly. In addition, it improves the control of the global EIS while reducing operational costs. Its application to a tour operator enterprise in the context of the proposed conceptualisation shows its practicability and the correlation between the structure of the EIS and the enterprise performance. It resulted in a reduction estimated from 5% to 15% of expenditure of maintenance costs and incidental; hence, urbanisation creates value. Moreover, it highlighted the advantages of EIS urbanisation using clustering techniques in terms of visibility and responsiveness.

Although this approach is important, it is not fully automated. So, the future work consists in implementing, checking and improving an integrated tool that will support the approach. It is planned to implement a prototype and estimate the pertinence of the approach in reality in comparison to others applied in the manufacturing industry. Another goal is to look for ways to improve the implication of humans and to progressively build a knowledge base that will interact with users.

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