

Interactive Exploration and Discovery of e-Government Services

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ABSTRACT

Government e-services available to citizens represent one of the most frequent and critical points of contact between public administrations and citizens. In addition to common services such as id cards, permits, e-services represent the only practical way of providing incentives and support to specific classes of citizens. For this reason, discovery of e-services, rather than plain retrieval, is a critical functionality in e-government systems. The solution we present in this paper is based on dynamic taxonomies, a semantic model for the transparent, guided, user-centric exploration of complex information bases. It provides a single framework for the access and exploration of all e-government information and, differently from mainstream research in semantic web, it is intended for the direct use of end-users, rather than for programmatic or agent-mediated access.

Categories and Subject Descriptors

H.3.3 [Information Storage and Retrieval]: Information Search and Retrieval – retrieval models.

I.2.4 [Artificial Intelligence]: Knowledge Representation Formalisms and Methods -- semantic networks.

General Terms

Design, Human Factors.

Keywords

Dynamic taxonomies, discovery of e-services, faceted classification.

1. INTRODUCTION

Although e-government research has an extremely wide scope, e-citizen access to public information is probably one of the most critical areas. The entire goal of e-government is to serve citizens, to let them participate in decisions and to improve their lives. Improving the life of citizens is possibly the single one justification of the vast amount of resources currently spent in e-government research. It is easy to argue that this goal implies that citizens need to have a complete, accurate and timely picture of all information that concerns or affects them. In short, no democracy without knowledge.

From this perspective, e-governments are vast repositories of knowledge that citizen must explore. Information available to citizens includes normative material (the official publication of laws and regulations) but also ancillary information such as job-brokering information [15] and, most importantly, information on the e-services the government offers. Currently, a typical e-

government portal provides 100-200 e-services, a number growing as more and more government agencies go online.

Services tend to be perceived by citizens as the public but also the friendlier face of government and are often far more interesting to the general public than laws and regulations are. However, It is already difficult for citizens, and becoming more so, to quickly and effectively find the right e-service. One of the main reasons for this difficulty is that access to services is considered by most portal designers as a search task rather than an exploration and discovery one. The two tasks are dramatically different: search paradigms imply that users know what they want and are able to specify it. On the opposite, an exploratory/discovery paradigm assumes that users do not know precisely what's in the information base, do not know exactly what they are looking for and are unable to specify requests without assistance. We contend that, apart from commonplace situations like renewing an id card, exploration and discovery are fundamental in finding the right items. As an example, many governments have special provisions for specific classes of citizens, e.g. citizen with disabilities. Such a citizen looking for housing needs to find out whether there are government aids for housing, but might be even more interested in finding out the entire extent of government aids that apply to her.

In the following, we briefly review traditional solutions and introduce dynamic taxonomies. Dynamic taxonomies have been proposed as a tool for the universal access of e-government information, from "institutional" information [14] to non-normative information such as job-brokering services [15]. In the present paper, we apply dynamic taxonomies to the end-user exploration and discovery of e-government services, showing that yet another important type of information can be effectively accessed through dynamic taxonomies which provide a single, universal access paradigm for a wide range of information access needs for e-governments.

2. CURRENT SOLUTIONS

The general problem of selection/discovery of e-services has traditionally been considered as a search problem rather than exploratory and addressed by traditional access paradigms, such as queries on structured database systems, and information retrieval. These methods retrieve data on the basis of precise specifications. However, as we remarked before, most search tasks, especially in the present context, are exploratory and imprecise in essence: the user does not usually know precisely what he wants (e.g. a specific service), but rather he needs to explore the information base, find relationships among concepts and filter alternatives out in a guided way.

It is intuitively appealing to consider solutions based on semantic networks [17] in the context of ontologies and Semantic Web [1, 4, 8]. This approach is quite expensive in terms of design and maintenance of complex conceptual schemata, and, although more powerful and expressive than plain taxonomies, is generally considered to be more difficult to understand and manipulate by the end user. It is better suited to programmatic access, and, consequently, user interaction must be mediated by specialized agents, which tend to lack transparency and suffer from many of the problems of knowledge-based systems [2]. The solution we propose in the following can also be used as a complement to complex ontologies: a taxonomy-based model that provides a user-understandable view on complex semantics [16].

Discovery of e-government services is usually addressed by general discovery techniques, so that there is no extensive specific research body. Fang and Liu Sheng [3] propose a data-mining approach that rearranges service links on the basis of the analysis of web-logs. This approach produces access portals that are personalized for an average citizen. While this speeds up the most common interactions, it offers no clue to the specific user on the right service for her, and it might well hinder discovery by directing the user to the most common service format. As an example, consider that most governments offer services for minorities: these services would be quite hard to find, by construction. In short, if personalization is needed, it is a personalization for the current user, rather than for an idealized average one.

3. DYNAMIC TAXONOMIES

Dynamic taxonomies [9, 10, 11] are a general knowledge management model for complex, heterogeneous information bases. It has been applied to very diverse areas [13], including e-commerce, multimedia databases, and diagnostic systems, and, in addition, art collections [5, 19], museums [6] and medical guidelines [18]. The intension of a dynamic taxonomy is a taxonomy designed by an expert. This taxonomy is a concept hierarchy going from the most general to the most specific concepts. A dynamic taxonomy does not require any other relationships in addition to subsumptions (e.g., IS-A and PART-OF relationships). Directed acyclic graph taxonomies modeling multiple inheritance are supported but rarely required

In the extension, items can be freely classified under several topics at any level of abstraction (i.e. at any level in the conceptual tree). This multidimensional classification is a generalization of the monodimensional classification scheme used in conventional taxonomies and models common real-life situations. First, an item is very rarely classified under a single topic, because items are very often about different concepts. Second, items to be classified usually have different independent features (e.g. Time, Location, etc.), each of which can be described by an independent taxonomy. These features are often called *perspectives* or *facets*.

By defining concepts in terms of instances rather than properties, a concept C is just a label that identifies all the items classified under C. Because of the subsumption relationship between a concept and its descendants, the items classified under C (*items(C)*) are all those items in the *deep extension* of C, i.e. the set of items identified by C includes the *shallow extension* of C (all the items directly classified under C) union the deep extension of C's sons. By construction, the shallow and the deep extension

for a terminal concept are the same. There are two important consequences of our approach. First, since concepts identify sets of items, logical operations on concepts can be performed by the corresponding set operations on their extension. Second, dynamic taxonomies can find all the concepts related to a given concept C: these concepts represent the conceptual summary of C. Concept relationships other than IS-A are inferred through the extension only, according to the following *extensional inference rule*: two concepts A and B are related if there is at least one item d in the infobase which is classified at the same time under A (or under one of A's descendants) and under B (or under one of B's descendants). For example, an unnamed relationship between Michelangelo and Rome can be inferred if an item classified under Michelangelo and Rome exists in the infobase. At the same time, since Rome is a descendant of Italy, also a relationship between Michelangelo and Italy can be inferred. The extensional inference rule can be seen as a device to infer relationships on the basis of empirical evidence.

The extensional inference rule can be easily extended to cover the relationship between a given concept C and a concept expressed by an arbitrary subset S of the universe: C is related to S if there is at least one item d in S which is also in *items(C)*. Hence, the extensional inference rule can produce conceptual summaries not only for base concepts, but also for any logical combination of concepts. In addition, dynamic taxonomies can produce summaries for sets of items produced by other retrieval methods such as information retrieval, etc. and therefore access through dynamic taxonomies can be easily combined with other retrieval methods.

Dynamic taxonomies work on conceptual descriptions of items, so that heterogeneous items of any type and format can be managed in a single, coherent framework. In addition, since concept C is just a label that identifies the set of the items classified under C, concepts are language-invariant, and multilingual access can be easily supported by maintaining different language directories, holding language-specific labels for each concept in the taxonomy.

The term *faceted search systems*, sometimes used instead of *dynamic taxonomies*, is a misnomer because: a) faceted classification only addresses conceptual modeling and very basic concept composition: conceptual summaries, reduced taxonomies and guided navigation are totally absent, and b) faceted classification is a special case of the multidimensional classification used by dynamic taxonomies.

4. INFORMATION ACCESS THROUGH DYNAMIC TAXONOMIES

The user is initially presented with a tree representation of the initial taxonomy for the entire infobase. Each concept label has also a count of all the items classified under it (i.e. the cardinality of *items(C)* for all C's). The initial user focus F is the universe (i.e. all the items in the infobase).

In the simplest case, the user can then select a concept C in the taxonomy and *zoom* over it. The zoom operation changes the current state in two ways. First, concept C is used to refine the current focus F, by intersecting it with *items(C)*; items not in the focus are discarded. Second, the tree representation of the taxonomy is modified in order to summarize the new focus. All and only the concepts related to F are retained and the count for

each retained concept C' is updated to reflect the number of items in the focus F that are classified under C' . The reduced taxonomy is a conceptual summary of the set of documents identified by F , exactly in the same way as the original taxonomy was a conceptual summary of the universe. In fact, the term *dynamic taxonomy* is used to indicate that the taxonomy can dynamically adapt to the subset of the universe on which the user is focusing, whereas traditional, static taxonomies can only describe the entire universe.

Figures 1 to 5 show how the zoom operation works. Figure 1 shows a dynamic taxonomy: the upper half represents the intension with circles representing concepts; the lower half is the extension, and documents are represented by rectangles. Arcs going down represent subsumptions; arcs going up represent classifications. In order to compute all the concepts related to H , we first find, in Figure 2, all the documents classified under H (that is, the deep extension of H , $items(H)$) by following all the arcs incident to H (and, in general, its descendants): $items(H) = \{ b, c, d \}$. All the items not in the deep extension of H (Figure 3) are removed from the extension. In Figure 4, the set of all the concepts under which the documents in $items(H)$ are classified, $B(H)$, is found by following all the arcs leaving each element in the set: $B(H) = \{ F, G, H, I \}$. The inclusion constraint implied by subsumption states that if $items(C)$ denotes the set of documents classified under C and C' is a descendant of C in the taxonomy, $items(C') \subseteq items(C)$ [11]. This is equivalent to say that a document classified under C' is also classified under C . Hence, the set of concepts related to H is given by $B(H)$ union all the ancestors of all the concepts in $B(H)$, i.e. the set of all concepts related to H is $\{ F, G, H, I, B, C, A \}$. Finally, in Figure 5, all the concepts not related to H are removed from the intension, thus producing a reduced taxonomy that fully describes all and only the items in the current focus.

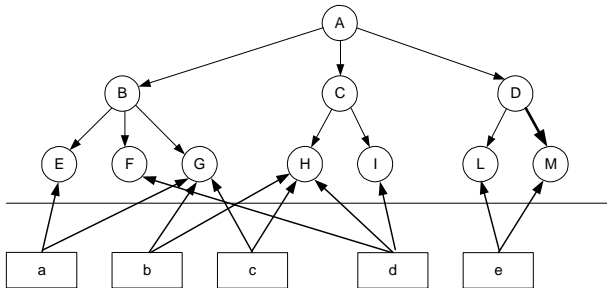


Figure 1 – A dynamic taxonomy: the intension is above, the extension below. Arrows going down denote subsumptions, going up classification

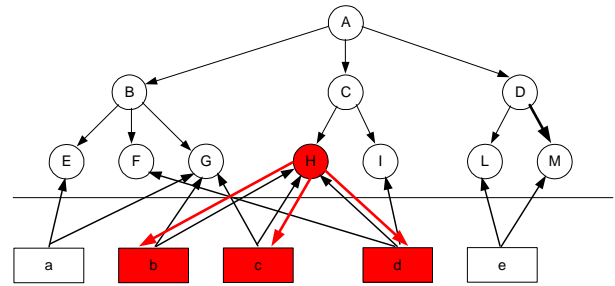


Figure 2 – Focusing on concept H: finding all the items classified under H.

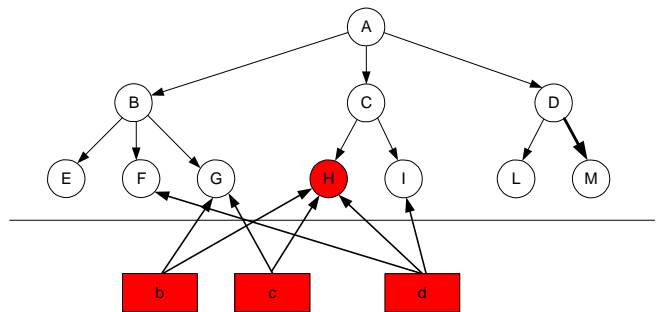


Figure 3 – All the items not classified under H are removed

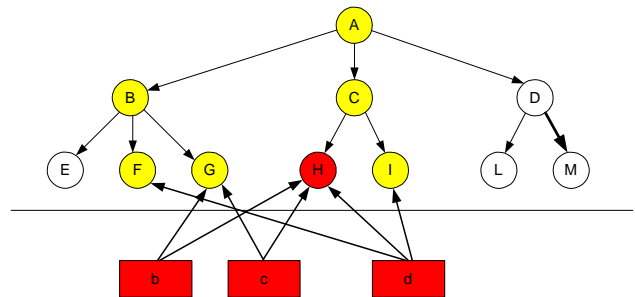


Figure 4 – All the concepts under which the items in the focus are classified (and, because of subsumptions) their ancestors are related to H.

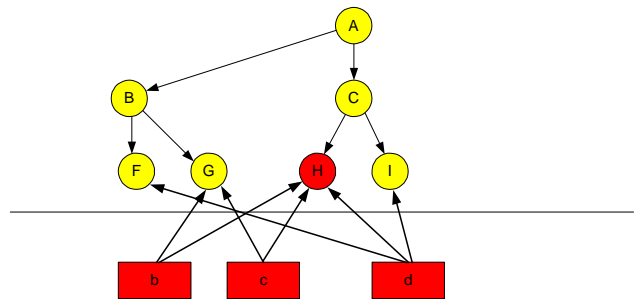


Figure 5 – Reduced taxonomy containing all the concepts related to H

The retrieval process is an iterative thinning of the information base: the user selects a focus, which restricts the information base by discarding all the items not in the current focus. Only the

concepts used to classify the items in the focus, and their ancestors, are retained. These concepts, which summarize the current focus, are those and only those concepts that can be used for further refinements. From the human computer interaction point of view, the user is effectively guided to reach his goal, by a clear and consistent listing of all possible alternatives.

Dynamic taxonomies can be integrated with other retrieval methods in two ways:

1. focus restrictions on the dynamic taxonomy provide a context for other retrieval methods, thereby increasing the precision of subsequent searches; or
2. the user can start from an external retrieval method, and see a conceptual summary of the concepts that describe the result.

These two approaches can be intermixed in different iteration steps during a single exploration. The integration of dynamic taxonomies with information retrieval is especially important because dynamic taxonomies can be used to describe abstract, conceptual queries and information retrieval can be used to define concrete queries (for instance proper names). By offloading conceptual manipulation to the dynamic taxonomy component, our practical experience shows that the information retrieval component needs not be very sophisticated, and in fact, a simple text retrieval system is usually adequate.

The advantages of dynamic taxonomies over traditional methods are dramatic in terms of an extremely fast convergence of exploratory patterns and in terms of human factors. Three zoom operations on terminal concepts are sufficient to reduce a 10 million item information base described by a compact taxonomy with 1,000 concepts to an average 10 items [12]. Dynamic taxonomies only require a very light theoretical background: namely, the concept of a taxonomic organization and the zoom operation, which seems to be very quickly understood by end-users. Usability tests on a corpus of art images [5, 19] showed a significantly better recall than text retrieval and, perhaps more importantly, the feeling that one has actually considered all the alternatives in reaching a result.

5. DISCOVERY OF SERVICES

Dynamic taxonomies cleanly separate the process of classifying documents from the use of classification information in the browsing system, and considerably simplify the design of the conceptual taxonomy. First, the extensional inference rule actually performs concept association mining: concept associations, which are often quite dynamic in time, need not be forecasted and accounted for in schema design. In addition, the user is presented with associations the schema designer might not even be aware of.

Second, since dynamic taxonomies synthesize compound concepts, these need usually not be represented explicitly, so that we avoid the exponential growth due to the description of all the possible concept combinations, and the resulting taxonomy is significantly more compact and easier to understand. Sacco [11] developed a number of guidelines for taxonomies that are compact and easily understood by users, and can be immediately applied to the present context. Some are similar to the basic faceted classification scheme by Ranganathan [7]: the taxonomy is organized as a set of independent, “orthogonal” subtaxonomies (facets or perspectives). As an example, a compound concept such as *housing for senior citizens* need not be explicitly accounted for,

because it can be synthesized from its component concepts: *Service>housing* and *Age>senior*, where *Service* and *Age* are facets.

In addition, breaking compound concepts into their base components allows the user to easily correlate concepts and explore such correlations. In the running example, the user focusing on *Age>senior* will immediately find all the relevant services related to senior citizens (which include *housing*). Most importantly, the interaction is completely symmetrical: the user will find *Age>senior* among the topics related to *Service>Housing* if he starts the other way round. If compound concepts are used (e.g. *housing for senior citizens*), correlation information is hidden inside labels, and cannot be carried out automatically but requires the manual inspection of labels. It must be mentioned that extensional inference in dynamic taxonomies derives *unnamed* relationships [11] among concepts, and, consequently, no specific relationship is accounted for by compound concepts as synthesized by dynamic taxonomies. As an example, dynamic taxonomies can derive *housing and senior citizens*, but not *housing for senior citizens*, unless a specific role disambiguation design is used [16].

Io sono...	Eventi della vita	Aree tematiche	Moduli on line	Servizi on line
Uomo Paternità, Salute maschile, Sexualità, ...	Donna Maternità e gravidanza, Salute femminile, Pari opportunità, ...			
Genitore Aspettando la nascita, Contributi e agevolazioni per i genitori, Mediazione familiare, ...	Bambino Alimentazione corretta, Biblioteche per bambini, Educazione e divertimento, ...			
Ragazzo Arti visive, Teatro e danza, Libri e letteratura, ...	Studente Associazioni studentesche, Biblioteche, Master, borse di studio e dottorati, ...			
Anziano Centri di assistenza e cura per anziani, Sicurezza in casa, Partecipazione alla vita pubblica, ...	Persona con disagio sociale Povertà, Dipendenze, Carcere, ...			
Disabile Benessere delle persone con disabilità, Contributi e agevolazioni per i disabili, Istruzione e formazione per i disabili, ...	In cerca di lavoro Orientamento e formazione, Curriculum e colloquio, Contratti e forme di lavoro, ...			
Italiano all'estero Assistenza sanitaria all'estero, Cittadinanza per gli italiani all'estero, Storia e memoria dell'emigrazione, ...	Immigrato Norme e leggi sull'immigrazione, Inserimento e accoglienza, Lavorare in Italia, ...			
Lavoratore Diritti sindacali, Lavori socialmente utili, Pensione, ...	Volontario Associazioni di volontariato, Come fare volontariato, Giovani e volontariato, ...			

Figure 6 – I am a ... from the Italian Government portal

Traditional approaches generally use a single, static taxonomy to describe services, since approaches based on Information Retrieval or database queries are obviously not beneficial in this present context. Services can be represented directly. A list of 20 basic public services that represent the minimal operation for administrations in the European Union is reported in Table 1. However, such a monolithic organization into services does not support exploration and requires that the user knows precisely the service he/she is looking for.

A competing, possibly more effective organization is on the basis of “life events”, i.e. events in the everyday life of a citizen. A static taxonomy portal organized in this way is the Italian government portal (www.italia.gov.it) that lists 16 life events ranging from “having a child” to “retiring” (Figure 6).

A static taxonomy only supports a single organization of services and consequently enforces a one-size-fits-all approach. In addition, it hides important features of services, such as grants to specific groups of persons.

1. Public Services for Citizens

2. Income taxes: declaration, notification of assessment
3. Job search services by labour offices
4. Social security contributions (3 out of the following 4):
5. Unemployment benefits
6. Child allowances
7. Medical costs (reimbursement or direct settlement)
8. Student grants
9. Personal documents (passport and driver's licence)
10. Car registration (new, used and imported cars)
11. Application for building permission
12. Declaration to the police (e.g. in case of theft)
13. Public libraries (availability of catalogues, search tools)
14. Certificates (birth, marriage): request and delivery
15. Enrolment in higher education / university
16. Announcement of moving (change of address)
17. Health related services (e.g. interactive advice on the availability of services in different hospitals; appointments for hospitals.)

18. Public Services for Businesses

1. Social contribution for employees
2. Corporation tax: declaration, notification
3. VAT: declaration, notification
4. Registration of a new company
5. Submission of data to statistical offices
6. Customs declarations
7. Environment-related permits (incl. reporting)
8. public procurement

Table 1 – Basic public services agreed upon by EU member states
http://europa.eu.int/information_society/eeurope/2002/action_plan/pdf/basicpublicservices.pdf

SERVICES	LIFE EVENTS	TYPE	WHERE ARE YOU	CITIZENSHIP	SPECIAL RIGHTS	PROFILE
Income taxes (20)	Having a child (12)	offline service (75)	abroad (15)	Italian (500)	Women (35)	Sex (539)
Job search services (3)	Studying (35)	online service (375)	Italy (524)	EU (480)	Senior citizens (67)	Age (539)
Social security contributions (12)	Working (67)	guide (89)		extra-EU (58)	Handicapped (86)	Education (539)
Personal documents (7)	Transportation (43)				Relationships (43)	
Car registration (4)	Housing (30)					
Application for building permission (25)	Family (55)					
Declaration to the police (15)	Paying taxes (67)					
Public libraries (9)	Going abroad (12)					
Certificates (40)	Health (60)					
Enrollment in higher education / university (7)	Sport (255)					
Change of address (4)	Police (35)					
Health related services (60)	Leisure and culture (44)					
	Helping others (12)					
	Retiring (16)					

Figure 8 – E-government portal with a dynamic taxonomy on seven facets

SERVICES	LIFE EVENTS	TYPE	WHERE ARE YOU	CITIZENSHIP	SPECIAL RIGHTS	PROFILE
Income taxes (2)	Working (2)	offline service (5)	Italy (67)	Italian (67)	Women (5)	Sex (67)
Social security contributions (10)	Transportation (13)	online service (62)		EU (4)	Senior citizens (67)	Age (67)
Declaration to the police (15)	Housing (7)	guide (19)			Handicapped (16)	Education (67)
Public libraries (9)	Family (5)					
Health related services (20)	Health (20)					
	Police (35)					
	Leisure and culture (14)					
	Retiring (16)					

Figure 9 – Reduced taxonomy after a zoom on Senior Citizens: characterization of the 67 items specifically targeted to senior citizens

A zoom on *Senior citizens* produces the reduced taxonomy in Figure 9, that shows all and only the topics classified under *Senior citizens*, i.e. those services/guides etc. that specifically apply to them. Drill-down can be iterated as required: for instance, the user might focus on *Housing*, thereby reducing both the number of items and the number of topics that apply.

This simple and easily understood organization has two important benefits with respect to traditional methods. First, users are guided to reach their goal no matter what their starting point is. Second, they are guided to discover all potentially relevant information: for instance, all services offered to *Senior citizens* (as in the example), or all the subjects that are entitled specific services in *Housing*. Incidentally, note that Figure 7 shows that there are specific services for Senior citizens that are women or have disabilities. No other technique currently offers this level of flexibility.

An English presentation is used here to stress the fact that dynamic taxonomies can easily manage multilingual information bases. In fact, in the present framework, a concept is just a label that identifies a set of items. Supporting a different language, as far as information access is concerned, only requires the translation of concept labels.

Although we did not show this functionality in the example, text retrieval is easily integrated, and dynamic taxonomies can be used

either to summarize the result or to prefilter it according to a conceptual context.

Finally, dynamic evaluation and display of relationships among concepts makes the evolution (insertion, deletion, update) of services especially easy to manage. In traditional, static designs, the addition of a new service or of a new information item can require a manual restructuring of a significant part of the existing portal. In dynamic taxonomy designs, the only action required is the classification of the new service or information item according to the dynamic taxonomy. The extensional inference rule takes automatically care of all the new correlations among topics established by the new item. So, whereas a new item requires changing the global schema in traditional designs, it only requires a local change in dynamic taxonomies. Such a local change consists in the classification of the new item, which is independent of any other existing items.

6. CONCLUSIONS

Dynamic taxonomies represent a dramatic improvement over other search and browsing methods, both in terms of convergence [12] and in terms of full feedback on alternatives and complete guidance to reach the user goal [19]. In addition, they provide multilingual access and easy integration with traditional search methods, such as text retrieval. An important point in the present context is that they can effectively manage an extremely wide range of e-government information, ranging from “institutional”

information [14], to non-institutional data banks such as job search services [15], to intelligent access to and discovery of services, as shown in this paper. In fact, they can be used as a single tool to solve most of the information access and dissemination needs of e-administrations. This implies lower IT costs but also, and most importantly, a lower cognitive effort required from e-citizens.

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