

Tailorable E-Government Information Systems

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INTRODUCTION

Real-world information, knowledge, and procedures after which information systems are modeled are generally of dynamic nature and subject to changes, due to the emergence of new requirements or revisions to initial specifications. E-government information systems (eGIS) present a higher degree of volatility in their environment, since requirement changes may stem from multiple sources, including legislation changes, organizational reforms, end-user needs, interoperability, and distribution concerns, etc. (Jansen, 2004; Prisma Project, 2002; Scholl, Klischewski, & Moon, 2005). To this end, the design and implementation of eGIS must adhere to paradigms and practices that facilitate the accommodation of changes to the eGIS as they occur in the real world. Object-oriented technologies have been extensively used to encapsulate reusable, tailorable software architectures as a collection of collaborating, extensible object classes; however the inherent conflict between software reuse and tailorability has inhibited the development of frameworks and models that would effectively support all requirements exposed by eGIS (Demeyer, Meijler, Nierstrasz, & Steyaert, 1997). The lack of such frameworks has led to eGIS that cannot easily be adapted to the new requirements, mainly because only the predetermined specifications are taken into account and design decisions are fixed during the implementation phase (Stamoulis, Theotokis, Martakos, & Gyftodimos, 2003).

A key issue to a viable solution eGIS modeling is the provision of the ability to multiple public authorities (PAs) to represent different aspects of the same real-world entity, while maintaining at the same time information consistency. Aspect representation is not only limited to data elements that describe the particular entity, but may extend to behavior alterations, when the entity is examined in different contexts. For example, an entity

representing the citizen is expected to assume the behavior of *beneficiary*, when used in the context of the Ministry of Social Security, and the behavior of *taxpayer*, when accessed from the Ministry of Finance's eGIS. Distinct behaviors may rely on different data representations and/or respond differently in requests. In this work we present a role-based modeling and implementation framework, which can be used for building eGIS and we argue that this model promotes the tailorability and maintainability of eGIS.

BACKGROUND

Currently, the representation of different real-world entity aspects is mainly achieved through the use of multiple, totally independent representations of the real-world entities, one per PA eGIS. Each representation encompasses the data elements, and models the behavior pertinent to the specific organization. Note that these data and behavior may include portions administratively regulated by other PAs, (e.g., the Ministry of Transport is administratively responsible for defining vehicle ownership-related data), however the Ministry of Finance eGIS should include such data, for taxation purposes.

At the other extreme of each eGIS having its own real-world entity representations, a single, centralized repository can be employed. According to this approach, some PA develops and maintains an eGIS, which is the authoritative source for both defining the schema and storing all data values for real-world entities. The schema must consolidate all data-related requirements of all PAs, while security rules can limit the access of any PA to the schema elements pertinent to its task(s).

Between the fully replicated and the fully centralized approach, a federated database approach (Chorafas & Steinmann, 1993) could be adopted, according to which

each PA eGIS defines a schema portion, which is *exported*. PA eGISs may also *import* schema portions that have been exported by other “federation members”, with each import augmenting the locally defined schema. The federated approach decentralizes schema maintenance tasks, with each PA updating the global schema portion for which it is responsible.

A methodology towards meeting both the requirements of multi-aspect modeling and context-specific behavior, while enhancing the overall system maintainability is the adoption of *two base constructs* for entity modeling: the first construct models fundamental behavioral system blocks, providing only the essential behavioral elements of the most abstract version of the modeled entity; this construct is termed *ATOMA* (Theotokis, 1997) and realizes the most basic collaboration and reuse contracts (Codenie, De Hondt, Steyaert, & Vercammen, 1997). Enhanced and context-specific behaviors are modeled using a second construct, namely *roles*, which are attached to atoma for modeling functional behavior related to a basic entity. Role attachment and removal can be performed dynamically, and multiple roles can be attached to a single entity, effectively modeling *facets* of this entity. Roles also implement their own collaboration and reuse contracts, through which operations are requested in the context of eGIS.

The Atoma framework is based on the concept of *separation of concerns* (Theotokis, 2003), which is a key concept in realizing deferred design decisions as it facilitates the notion of “injectable” behavioral adjustments in existing operational eGIS. The *ATOMA* model allows object-oriented design and code to be decomposed into units, describing basic behavior, as this is captured during the initial design phase from the contractual requirements, and units that specify either variations or changes to these requirements, or new requirements, as these emerge in time. Both at design and implementation level, the former are represented as standard object-oriented classes, while the later are roles that, when composed with classes, realize the ever-emerging requirements. Each role can therefore be refined separately to a code artifact, and the details of the code composition can be derived from those of the design composition.

THE ROLE-BASED MODEL FOR TAILORABLE E-GOVERNMENT SYSTEMS

eGIS Modeling Using the Atoma Framework

According to the atoma framework, for each real-world entity, a single atoma construct is defined, which encap-

sulates the fundamental data and functionality needed for managing this entity. The PA eGIS within which the construct is defined may be chosen on the basis of various criteria, such as administrative responsibility, technical know-how, expected access patterns and so forth. Once the construct for modeling a real-world entity has been defined, it may be *exported* for use by other eGIS, which will *import* this construct. Each eGIS also provides implementations for the roles that will be assigned to the atoma to be used within its context, either locally defined or imported. For example, the Ministry of Transport may define the roles *taxi* and *bus* that will be assigned to atoma of type *vehicle* (locally defined), while the Ministry of Finance may define the role *taxpayer*, which will be assigned to atoma of type *person*, a type imported from the Ministry of Social Security. Correspondence between roles and atoma types is not necessarily one-to-one: the Ministry of Finance may define the *taxable good* role, which can be assigned to atoma of types *building*, *car*, *value-added service* and so on. The communication between a role and the atoma construct to which it has been assigned is based on the collaboration and reuse contracts provided by the atoma construct; thus, the *taxable good* role can be assigned to any atoma construct that implements the collaboration contract *price*, which will be invoked to obtain the net price (before taxation) of the relevant real-world entity. During the period that an entity is assigned the *taxable good* role, its behavior is enhanced with the operations defined in the role (e.g., *tax amount*), while some of its operations may be overridden by respective ones implemented by the role (e.g., the *price* behavior will be redefined to return the net price plus the tax due). Note that both the role and the underlying entity may independently evolve without any disruption in their communication, as long as the collaboration contracts are respected. Moreover, the interaction between a role and the eGIS it is used within will function properly, as long as the existing elements of the collaboration contract implemented by the role are not altered (new elements may be added with no side-effects).

Similarly to atoma constructs, roles can also be *exported* by the PA eGIS that has defined them and imported by other PA eGIS for use, if the functionality they provide is useful in the context of the importing eGIS. For instance, the *taxable good* role, defined by the Ministry of Finance, may be imported by the Ministry of Commerce and assigned to atoma constructs, either locally defined (e.g., *value-added service*) or imported (e.g., *car*).

Maintaining Role-Based eGIS

When a new requirement is added or an existing one is changed, a new design aspect (a role) is created to address it. The new design aspect can then be composed with the

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