Enabling Workflow Composition within a Social Network Environment

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Abstract. Social networks have emerged as a new paradigm for everyday communication, as well as for promoting collaboration within enterprises and organizations. Using current technology, social network participants not only exchange information but also invoke external applications in the form of gadgets. In order to provide enhanced, complex functionality to participants, enabling them to complete a specific business task, workflow composition based on gadget combination could be supported. In such case, gadgets executed in the context of a user profile may add or update information stored in it, while the profile owner is responsible to combine them. In this paper, we explore how to support such features, based on a recommendation mechanism, which automatically produces gadget composition plans, based on intelligent techniques. This context-driven process provides efficiency in cases when a large number of gadgets is available in a social network. The main contribution of the proposed framework lies in the fact that users are only expected to state the content to be added in their profile; the recommendation mechanism can then automatically discover and combine the appropriate gadgets, proposing a solution; no predefined workflows or any other knowledge of the available gadgets is required. The proposed mechanism supporting gadget composition promotes the adoption of social networks as a novel paradigm not only for content sharing and collaboration but also for business process management within the enterprise.

Keywords. Social BPM; social network; Enterprise 2.0; recommendation mechanism; workflow composition.

Introduction

Social networks have emerged as a new model for communication and interaction between individuals, as well as among members of enterprises, communities or organizations [1]. Currently, there are numerous social network platforms, enabling user communication in everyday social life and competing with each other in terms of popularity, by continuously offering enhanced functionality, advanced features, external service invocation and integration with other social networks [26][27]. At the same time, not only individuals but also enterprises and organizations incorporate novel interaction models based on private social networks, serving a specific community, for knowledge dissemination, communication and collaboration between their members [18][2][12].

Collaboration in a typical social network is performed through exchange of information and notifications in a distributed fashion. In addition to sharing content, the social network model also supports the provision of functionality in the form of *gadgets*, which are external applications executed in the context of the social network, able to access participantôs data stored in their profiles. Usually a gadget implements the invocation of an external application, commonly in the form of web services and is executed in the context of a specific user profile, often using as input data stored in the userôs profile, as for example age or gender. Thus, gadgets in most social networks are able to read data from the user profile, while writing in it is prohibited to minimize complexity and simplify security enforcement.

To support BPM in a social network environment, a participant should be able to achieve a specific task by composing a workflow based on available gadgets, possibly in co-operation with other participants. In order to be combined, gadgets should be allowed to both use and alter the content of the user profile, e.g. to read and to write or update data stored in it. Such a feature can be easily supported in private social networks, where participants belong in a specific organization/community and can be authorized to access or share specific content, based on their role/position in the community. An example of such an environment is Unity private social network, developed by the authors to support collaboration in a University community[31].

Workflow composition can be facilitated by allowing social network participants to execute specific gadgets based on the context of their profile, which in turn is enriched by gadgets outputs. A gadget can be executed when its input data is missing, which may be produced by the execution of other gadgets, which, in turn, might require more data, leading to the execution of additional gadgets, and so on. As the number of available gadgets increases, this process becomes burdensome and inefficient; therefore, the ability to automatically determine and recommend gadget combinations that fulfils the participantsô needs to support workflow is essential. Furthermore, in many case a participant may be aware of the content he/she wishes to be added in their profile, but has no knowledge of the workflow to produce it. Instead, the only truly feasible solution is automated composition, aided by intelligent techniques; such techniques enable the provision of appropriate composition plans, which represent workflows for task completion. Supporting automated gadget composition in a social network may enable service provision and lead to the accommodation of business process management through the social network paradigm [17][5][6][8][11][24].

This paper concerns a) the exploration of the dynamic composition of workflows in a social network by network participants and b) the development of a recommendation mechanism to assist participants to determine workflows based on alternative gadget combinations and the content of their profile, using intelligent techniques. The produced solutions enable social network participants to achieve specific goals by adding the desired content in their profile, possibly in collaboration with other participants. The proposed recommendation mechanism utilizes existing methods and tools and has been integrated and tested within Unity private social network platform. The rest of the paper is structured as follows: Section II provides some background information concerning the social network collaboration paradigm and systems in the area of service composition through intelligent techniques. Section III elaborates on the proposed mechanism, while Section IV provides case studies. Finally, section V concludes the paper and proposes future directions.

Background and Related Work

Social network platform functionality, offered in the form of gadgets, has been utilized to enable the completion of specific tasks within collaborative communities, including organizations or enterprises, which are supported by private social networks [31]. For collaboration purposes, processes can be treated as business goals reached after completing specific tasks, which may be performed by a specific participant and may involve the invocation of external services to be completed. Each task corresponding to a specific process step is handled by a gadget, which may only be executed in the participantôs profile.

In order for collaborative processes to be supported, inter-gadget communication must be enabled. Based on available social network technology, gadgets may access and store data in a specific area of the profile they are executed on, as well as in external profiles as well, under certain conditions. For communication purposes, gadgets are described in terms of their inputs and outputs ï represented as concepts; a concept may serve as both the input of a specific gadget as well as the output of another. A gadget is allowed to start its execution only when all input data is available.

Generally, each gadget is supposed to implement a simple, basic task, thus promoting reusability; more complex tasks can be achieved by the combination of more than one gadgets. Business process modeling can be achieved by representing each business process as a task, implemented by a simple gadget ï in order for the entire process to be completed, a combination of gadgets has to be achieved.

In the case where the number of available gadgets increases, it is difficult ï if not practically impossible ï for a participant to know which gadget to execute to produce a specific output they wish to be added in their profile. In many cases, there is more than one gadget that could potentially produce this output. Moreover in many cases this gadget cannon be executed unless other gadgets are executed first, most probably in a specific order. This indicates the need to establish a recommendation mechanism, which enables a social network participant to efficiently utilize an existing gadget repository supported by the social network to achieve a specific goal, e.g. to add specific data to their profile. Automatic workflow specification, based on gadget combination, can be performed through intelligent techniques; this paper proposes a mechanism for automatically generating such workflows using AI Planning.

The problem of automatically determining workflows that satisfy enhanced functionality by combining functional components in highly dynamic environments has emerged and has been studied in the past, in the form of web service composition. At the same time, research in this area has shown that we can take advantage of well defined and long studied techniques from artificial intelligence, and apply them to solve problems from different domains. During the design of the proposed recommendation mechanism, similarities between gadgets and web services were identified; therefore, it was possible to use the same intelligent techniques proposed for web service composition and adapt them to the gadget & social network environment.

To the extent of our knowledge, gadget composition through intelligent techniques has not been presented in the literature; however, composition of functional units, such as components as web services, has been extensively studied [8][37][30][4][35][13]. Therefore, the remainder of this section presents related approaches as a foundation for the proposed recommendation framework.

Automated approaches typically involve representation of the composition problem in such a way that well-defined and long-studied AI techniques can be utilized to obtain solutions to the problem [38][35][30][36]. A critical evaluation of the related systems reveals that the utilization of AI planning for automated web service composition provides significant advantages, including the independence of problem representation from problem solution [36][33][25], increased interoperability by conformation to current standards [15], and increased scalability, as indicated in [22][23]. AI Planning has been extensively utilized to provide solutions in similar problems where component composition is performed based on inputs and outputs; such frameworks can benefit from both the solid foundation as well as the ongoing research advances in this area. At the same time, external independent planning tools are available and accessible over the web, communicating using XML based standards, as the Planning Domain Definition Language (PPDL) [15], promoting interoperability. This permits the proposed approach to utilize existing tools.

Proposed Framework

The framework proposed in this paper concerns a mechanism which utilizes intelligent techniques to automatically produce recommended gadget composition plans. This process is context-driven and accommodates user requirements for complex functionality. In particular, the recommendation mechanism is employed in the social network, when a user wishes to complete a goal by identifying the content required to be added to their profile. To do so, they should select to perform certain tasks (e.g run gadgets), out of a large variety of available ones. In this case, participants know *what* they want to do (the result) but not exactly *how* to do it (process steps). Both user requirements and available gadgets are described in terms of data exchanged; therefore, the recommendation mechanism is able to match user requirements to gadget inputs and outputs, and formulate a composition plan that might include serial and/or parallel steps, each step representing a gadget execution.

Evidently, the recommendation mechanism needs to be aware of all available gadgets in the social network; more specifically, it requires knowledge of their inputs and outputs. Currently, there is not a commonly accepted standard for describing gadgets in a social network; to overcome this, the proposed framework includes an extension to the standard OpenSocial / Shindig database, depicted in Fig. 1. This extension accommodates the creation of a gadget registry, where the definition of concepts is separated from their use as gadget inputs and outputs; this representation is indicated for cases when developers need to use a common vocabulary (e.g. an ontology) for defining gadgets.

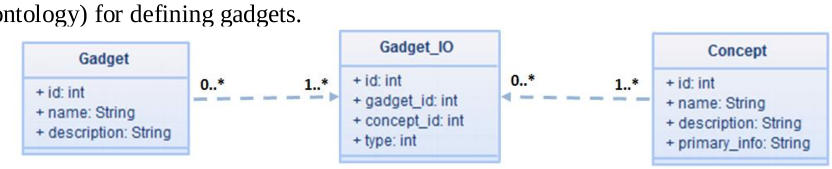

Fig. 1. OpenSocial Database extension implementing gadget registry.

The recommendation mechanism utilizes intelligent techniques, namely AI planning, in order to accommodate reusability and scalability. The problem of combining gadgets in order to come up with a composition plan of a workflow that fulfills usersô needs can be transformed into an AI Planning problem and solved using existing domain independent planning systems. Thus, it ulilizes existing tools available in the Internet.

A planning problem is modelled according to STRIPS (Stanford Research Institute Planning System) notation [14] as a tuple $<I,A,G>$ where I is the Initial state, A is a set of available actions and G is a set of goals. States in STRIPS are represented as sets of atomic facts. Set A contains all the actions that can be used to modify states. Each action A_i has three lists of facts containing the preconditions of A_i (noted as $prec(A_i)$), the facts that are added to the state (noted as $add(A_i)$) and the facts that are deleted from the state (noted as $del(A_i)$). An action A_i is applicable to a state S if $prec(A_i) \subseteq S$. If A_i is applied to S, the successor state Sô is calculated as Sô = $S \setminus del(A_i) \cup add(A_i)$. The solution to a planning problem is a sequence of actions, which, if applied to I, lead to a state Sô such that Sô $\supseteq$ G.

In order to acquire solutions, a planning problem can be forwarded to external planning systems, as the one presented in [21].

In order to solve a gadget composition problem as a planning one, the required steps are as follows:

Step 1. The gadget composition problem must be transformed into a planning problem.

Step 2. The planning problem must be encoded in a planning standard, such as PDDL; as a result, the planning domain and problem are produced.

Step 3. The planning problem will be forwarded to external planning systems, which will produce as a solution a composition plan.

Step 4. The composition plan must be reversely transformed into the social network domain, the corresponding gadgets must be located and possibly visualized.

The aforementioned steps are depicted in Fig. 2.

Step 1 of the process discussed above, which includes the representation of a gadget composition problem in planning terms, requires gadgets to be viewed as actions, and compositions to be viewed as plans. More specifically, the representation of the gadget composition problem to a planning problem can be performed by applying the following rules:

- The set of all available inputs that the user can provide to the social network formulates the initial state I of the planning problem. In order to release the user from the obligation to provide a list of every available piece of information that they could potentially provide, we can safely assume that this list can be automatically populated by all inputs of available gadgets that cannot be produced as outputs from other available gadgets.
- The set of all available outputs that the user requires to receive by the desired functionality formulates the goal state G of the planning problem.
- The set of all available gadgets in the social network formulates the set A of actions of the planning domain. More specifically, each gadget is transformed into an action; the inputs of the gadget serve as the preconditions of the action, while the outputs of the gadget serve as the results of the action.

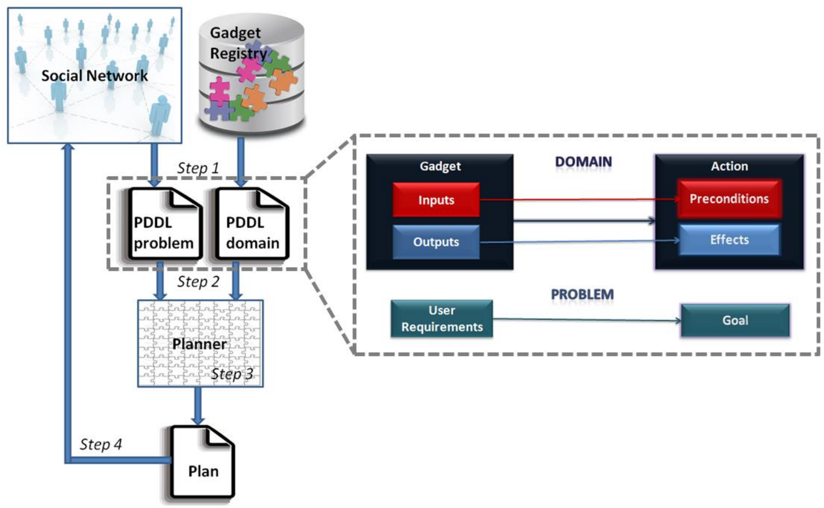

Fig. 2. Proposed recommendation framework utilizing planning

The produced plan will enable to determine the combination of gadgets that can be executed to perform the requested collaborative task. In case when alternative plans exist, due to the fact that certain outputs are produced by more than one gadgets, the planner is able to produce all of them. Also, in case when certain inputs do not exist in the social network the proposed framework is able to produce partial plans and indicate that certain gadgets which would be required to complete the process are missing.

Case Studies

The proposed mechanism can be employed in a variety of cases with the following characteristics:

- Highly dynamic environments, where available gadgets change, as new gadgets are added in the social network while other become unavailable.
- Social networks with a large number of available gadgets from different developers, where it is difficult to be aware of all of them and locate suitable ones.
- Cases where user requirements for functionality are complex but not predefined; that is, environments where users require services on demand.
- Social network environments which integrate a variety of external software systems as gadgets; such social networks concern for example e-administration [20] or e-government [10].

The proposed recommendation mechanism application and evaluation was accommodated by Unity, an academic social network implemented at the Department of Informatics and Telematics of Harokopio University of Athens to promote collaboration within faculty, staff and students of the Department [20][31]. Unity features discrete roles for participants and different kinds of relations between them, based on these roles. The Unity social network incorporates functionality in the form of gadgets; each gadget is an application that can be installed on a participant profile and gain read & write access rights to their profile data. In many cases, the gadget can also gain access to data in the profiles of other participants, in order to promote collaboration. The installation and execution rights of each gadget, as well as the permissions for data access are governed by a security mechanism based on a set of rules which take into account the participants roles and relations between them. Each gadget corresponds to a specific task that a participant can perform. Members of the academic community can receive electronic services through the Unity platform by requesting certain data to be added to their profiles. In case this data is produced not by a single gadget, but a combination, the proposed recommendation mechanism is employed. The recommendation mechanism was incorporated as a component in the Unity social network, facilitating users in determining gadgets compositions which fulfill their needs.

Unity implementation is based on the extension of OpenSocial API and Apache Shindig. A screenshot of the interface of the academic social network constructed using the Unity platform is depicted in Fig. 3. The left part of the profile contains the participant role and their connections with other participants, while the middle part includes all notifications about activities. Finally, the right part of the profile is reserved for gadget execution.

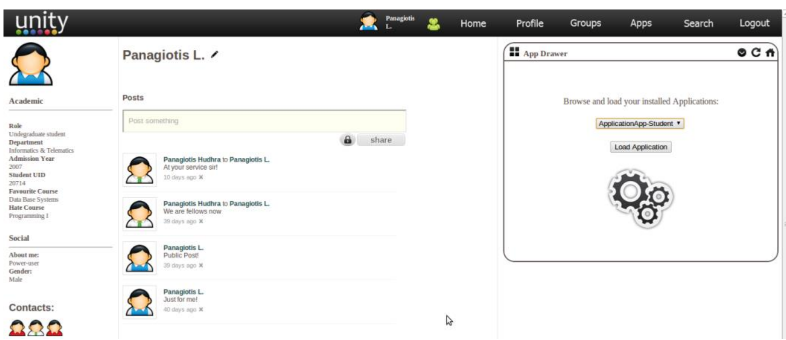

Fig. 3. Screenshot of an example profile of the Unity academic social network.

As an example, the graduation application process is considered. In order to be eligible for graduation, a university student must fulfill the following requirements:

- All courses have been successfully completed.
- The degree thesis has been submitted to the University Library.
- All books borrowed from the University Library have been returned.
- The student ID, transportation card and thesis certificate have been returned.

The student can subsequently fill out a graduation application form and submit it to the Department Secretariat, who confirms that all requirements are valid and notifies the student of the graduation ceremony date.

When the user attempts to perform this task through the Unity academic social network, he or she is not expected to be aware of all these requirements; they are just expected to ask for their graduation date to be added on their profile; this data is produced by the corresponding ñGraduation Applyò gadget. Since this specific gadget requires input not already present in the student profile, the recommendation mechanism is employed. Student requirements are viewed as a gadget composition problem and transformed into a planning problem (Step 1). Consequently, the planning problem is encoded in PDDL (Step 2); the corresponding PDDL files (problem & domain) are depicted in Fig. 4 and Fig. 5 respectively.

```
(define (problem gadgetproblem)
(:domain states)
(:objects aaa)
(:init (block aaa)
 (Name aaa)(Lastname aaa)(Library_Username aaa)(RN aaa)
(Identification_Card_Number aaa)
(Social_Security_registration_number aaa))
(:goal  (Date_Graduation_Apply aaa)))
```

Fig. 4. PDDL problem file for the problem of graduation application.

```
(define (domain states)
 (:predicates (block ?b)
 (Name ?b) (Lastname ?b)
 (Library_Username ?b) (RN ?b) (No_Dept_Books ?b)
 (Thesis_Submitted ?b) (None_Remaining_Courses ?b)
 (Graduation_Documents_Submitted ?b) (Date_Graduation_Apply ?b)
 (Identification_Card_Number ?b) (Social_Security_registration_number ?b)
 (Calculation_Contribution_Valid ?b) (Insurance_Number_Valid ?b)
 (Taxpayer_Identification_Valid ?b) (Calculated_Amount_Paid ?b)
 (Wage_Period_Valid ?b) (Electronic_Contribution_Valid ?b)
 (Code_Retrieval_Payment_Receipt ?b))
(:action Library_Book_Account
   :parameters (?b)
   :precondition (and (block ?b) (Name ?b) (Lastname ?b)
       (Library_Username ?b) (RN ?b))
   :effect (No_Dept_Books ?b))
(:action Library_Thesis_Submission
   :parameters (?b)
   :precondition (and (block ?b) (Name ?b) (Lastname ?b)
       (Library_Username ?b) (RN ?b))
   :effect (Thesis_Submitted ?b))
(:action Remaining_Courses
   :parameters (?b)
   :precondition (and (block ?b) (Name ?b) (Lastname ?b) (RN ?b))
   :effect (None_Remaining_Courses ?b))
(:action Graduation_Documents
   :parameters (?b)
   :precondition (and (block ?b) (Name ?b) (Lastname ?b) (RN ?b))
   :effect (Graduation_Documents_Submitted ?b))
(:action Graduation_Apply
   :parameters (?b)
   :precondition (and (block ?b) (None_Remaining_Courses ?b)
        (No_Dept_Books ?b) (Thesis_Submitted ?b)
              (Graduation_Documents_Submitted ?b))
   :effect (Date_Graduation_Apply ?b)))
```

Fig. 5. PDDL domain file for the problem of graduation application.

The planning problem is the fed to the LPG-td planning system [16] (Step 3), which produces the plan presented in Fig. 6.

```
0:   (REMAINING_COURSES AAA) [1]
0:   (LIBRARY_BOOK_ACCOUNT AAA) [1]
0:   (LIBRARY_THESIS_SUBMISSION AAA) [1]
0:   (GRADUATION_DOCUMENTS AAA) [1]
1:   (GRADUATION_APPLY AAA) [1]
```

Fig. 6. Gadget composition plan, produced by LPG-td.

The plan is consequently reversely transformed into the gadget domain and visualized with JQuery (Step 4), as depicted in Fig. 7.

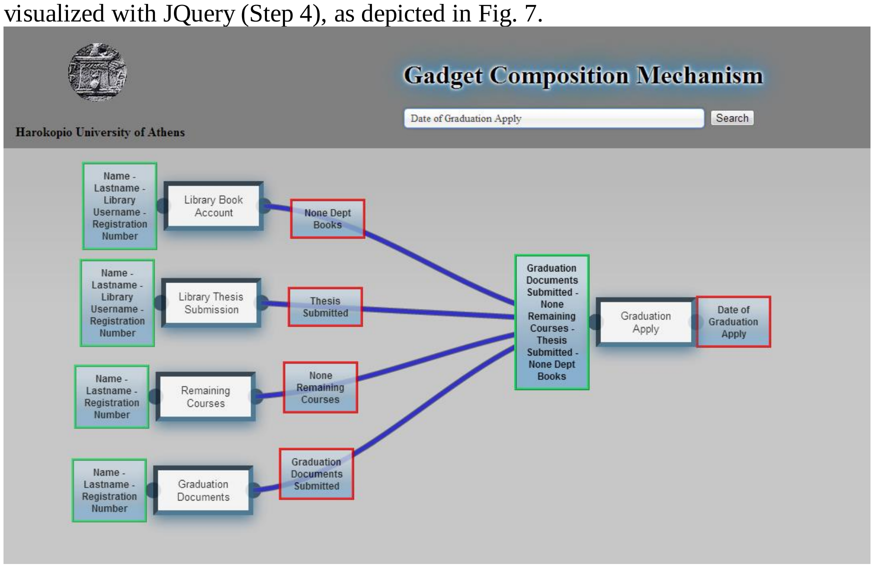

Fig. 7. Gadget composition visualization.

To explore the applicability for the e e-government case, the recommendation mechanism is incorporated in the social network model proposed in [9]. As an example, consider the following scenario.

An employer wishes to pay the insurance tax for their employees through web banking, and receive an electronic receipt for the payment. The employer does not need to know neither the prerequisites for this process, nor all the available gadgets that produce these prerequisites and the rest of the required information. The employer only needs to specify their needs; the recommendation mechanism will take over the rest of the process, locate the appropriate gadgets and inform the employer of the produced workflow, which includes the following steps:

- The amount of insurance for each specific employee is calculated based on their identification data and their social security number; for security purposes, redundant data is required.
- The employer needs to locate his Employer Identification Number, his Social Security number, and state the amount of insurance payment, as well as determine the time period that this amount corresponds to.
- If all gadgets required in the previous step are executed successfully, the gadget that integrates the bank web service is activated and the payment takes place.
- Finally, another gadget produces the payment receipt and provides it to the employer profile.

The produced gadget composition, transformed back into the social network domain, and represented as specific gadgets along with their inputs and outputs is depicted in Fig. 8.

The case studies in this section indicate the applicability of the approach as far as social networks that conform to contemporary OpenSocial standard are concerned. More specifically, the case studies demonstrate the representation of the available gadgets in the social network, the way participants are able to express their requirements for service provision or task completion, and the way gadget compositions are provided automatically as a solution to the problem at hand. The Unity case study validates the feasibility of the approach, since it was implemented in a real-world academic environment, accommodating processes that take place in the University. The e-government case study, on the other hand, expands the application area of the proposed recommendation mechanism and provides insight its usability for highly dynamic, heterogeneous environments. The case studies also demonstrate that the incorporation of the proposed recommendation mechanism in a social network promotes gadget development while relieving users from the obligation to manually discovering and combining functionality.

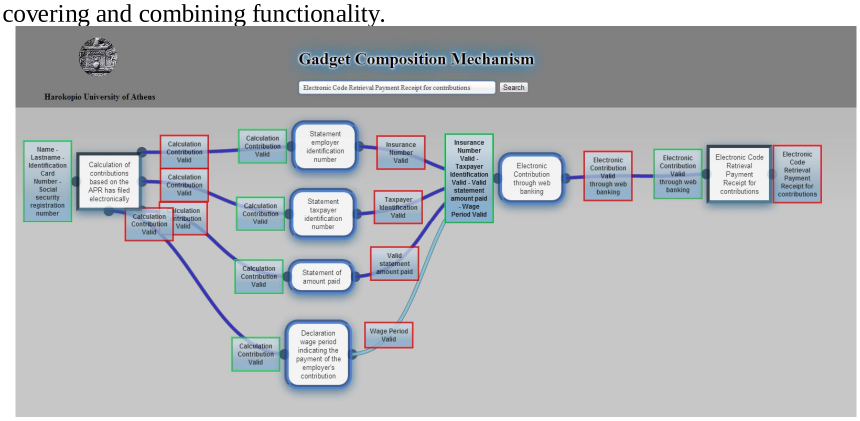

Fig. 8. Gadget composition for the electronic insurance payment case.

Conclusions and Future Work

As social networks become a widespread paradigm for collaboration and service provision, a requirement for more elaborate methods to manage and discover functionality offered through gadgets emerges. The proposed recommendation mechanism relieves users from the obligation to manually search among all available gadgets and consequently construct a workflow, thus contributing to increased efficiency when utilizing a social network for service provision, for example in an e-administration or e-government context.

The applicability of the approach has been demonstrated by incorporating the recommendation mechanism to Unity existing social network. Participants only need to specify their requirements, in terms of desired outputs added in their profile as content; the recommendation mechanism transforms the gadget composition problem into a planning problem and uses external planning systems to obtain solutions.

A major issue that needs further exploration in the future is gadget descriptions semantic interoperability. Currently, in order for the planning system to be able to match gadget inputs to gadget outputs successfully, syntactic interoperability must be guaranteed; in other words, the concepts used for describing gadget inputs and outputs much be exactly the same. This was guaranteed in the aforementioned examples, since all gadgets were developed by the same party, using the same vocabulary. However, in a more general case, it cannot be expected that all gadget developers will use the same vocabulary; therefore, interoperability between semantically related by syntactically different concepts must be ensured. Ontologies, Taxonomies and Lexical Thesauri, such as WordNet, could prove potentially useful for establishing such interoperability.

Future work also includes refinement of the mechanism to take into account additional restrictions, imposed by security rules that allow the execution of gadgets based on participant roles and relations between them. In such cases, the proposed composition should include different stakeholders, depending on the participant that should execute each gadget. Finally, future goals include more extensive evaluation of the recommendation mechanism in intensive social network environments, where previous recommendations may be used to facilitate efficiency.

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