Modeling Evolving Human User Engagements with Cognitive Advisory Agents using the i* Framework

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Abstract. Organizations are increasingly looking to adopt and incorporate cognitive capabilities into key business processes (BPs) to aid their human decision-makers. Integrating advanced cognitive systems into enterprise BPs is difficult as one needs to consider not only enterprise objectives, but the social and organizational impact of these systems' as they, for instance, affect human decision-makers and other roles. Conversely, BPs and the processes responsible for managing how human users engage with cognitive systems need to be designed to enable users to adapt to the enhanced capabilities of such systems. Redesigning cognitively-enhanced BPs may also require changes to additional supporting processes, which can emerge and evolve over a period of time to monitor, evaluate, adjust, modify, or audit the main BPs. Together these processes constitute a business process architecture. This paper uses the i* framework to model, analyze, and visualize the engagements between human process participants and cognitive business agents and aid in the selection of appropriate BP configurations that match the needs and capabilities of both human and system actors. This approach supports better integration of cognitive systems and BPs pertaining to cognitive decision-making.

Keywords: Cognitive Computing, Enterprise Cognitive Systems, Business Process Architecture, Actor Modeling, Goal Modeling

1 Introduction

The ever-increasing amount of relevant business data, the affordable and flexible cloud-based storage, compute and other services, and the growing sophistication of algorithms all contributed to the resurgence of AI – and machine learning (ML) in particular – in recent years. Given high competitive pressures, customer expectations, etc., organizations are increasingly looking to adopt and incorporate cognitive (i.e., ML-based) capabilities into key business processes (BPs) to aid human decision-making. However, integration of advanced cognitive capabilities (such as those when automated systems produce advice for humans responsible for making complex decisions or even enact changes due to automatically produced decisions) into enterprise

BPs is difficult as the success of this integration is predicated upon the achievement of not only enterprise functional and non-functional objectives, but also the personal goals of process participants (i.e., human decision-makers).

Organizations and human decision-makers are affected by cognitive systems since their introduction affects the distribution of work and responsibilities in the organization, may threaten human workers' job security, self-esteem, job satisfaction, personal growth, etc. and can potentially create tension, suspicion, rejection, etc. in the affected employees, which in turn may impact organizations' stability, performance, etc. Thus, the social and organizational acceptance of cognitive systems is of paramount concern and needs to be analyzed in addition to determining whether these systems perform well (i.e., produce decisions of high quality). When it comes to using cognitive systems (we call them Cognitive Business Agents, CBAs) to help decision-making in enterprises, we can identify a number of options ranging from a fully manual configuration (where a human decision-maker is wholly responsible for gathering data and making the decision), through collaborative options (where CBAs advise humans), to fully automated ones (with systems taking over decision-making from humans). Each of these options corresponds to a set of interactions between humans and CBAs (e.g., communicating or explaining decision recommendations) – we refer to these as *user engagements* (UEs, see [1] for details).

i*, being a social modeling framework, has the capability to support the above analysis. It is able to explicitly represent not only roles, but also agents (human and automated) playing those roles, with their personal objectives that can be analyzed over and above those of the roles they are playing. Intentional dependencies, goal/task refinement, and qualitative softgoal evaluation helps model the distribution of responsibilities in various types of user engagements with cognitive systems and analyze how those options meet organizational goals and personal goals of the involved agents. Such engagements cannot be static and need to be managed concurrently with the cognitively-enhanced BPs, CBAs, and supporting user engagement management processes, which necessitates focusing on BP architectures (BPAs) [2] rather than on individual BPs [3]. In this paper, we propose an approach to link BPAs and i* models to support the above-described analysis, with i* models helping to select the right BPA configurations which correspond to particular user engagements with CBAs. The method is illustrated using a loan approval example.

2 Modeling Evolving User Engagements With Cognitive Agents

2.1 Motivating Example

We take the example of a loan approval business process in a typical enterprise that is considering the adoption of CBAs to help attain certain business objectives, modeled as non-functional requirements (NFRs). Human workers would need to discover how to best work with these cognitive agents, while the CBA would need to be integrated while considering adoption success factors such as the capabilities of the cognitive agent, its limitations, ability to learn and adapt, etc. As CBAs become more sophisticated, changes in user engagement affecting multiple BPs are necessary to enable users and organizations to adapt to the systems' new capabilities. Similarly, user engagement can also evolve to accommodate changing user capabilities and attitudes (with trust being the prominent one), requirements, and contexts. Thus, both sides here will need to adjust and eventually converge to a workable state while continuously evolving as the cognitive agent gets better through machine learning, or gets new features, and on the user organization side, as the personnel gain experience or learns new skills. i* can help identify the best user engagement option based on organizational objectives, CBA capabilities, and current user attitudes (e.g., the level of trust in that CBA) as well as analyze how transitions to more (or less) automated user engagements will affect the organization and the involved human users. We use this motivating example to lay the foundation for a systematic modeling approach that enables reasoning about why one form of engagement approach between human agents and CBA works but another does not.

2.2 Associating Actor Models with Process Models

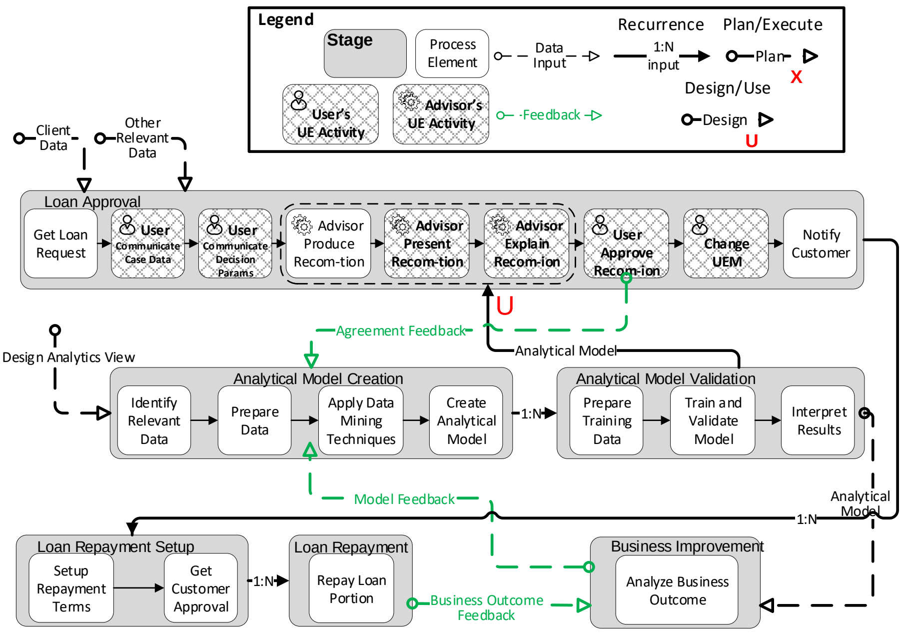

Fig. 1. BPA for a loan approval scenario with manual approval of automated recommendations

We have introduced process architecture models as part of previous work [2]. Unlike traditional process-oriented modeling techniques (such as BPMN [4]), this modeling technique is not limited to depicting the (sequential) execution of process activities, information and data flows, and the inclusion of software artifacts in the process structure. Rather, this framework attempts to show the *architectural* relationship between process segments so as to enable the redesign of the overall process architecture while considering multiple change dimensions. This is done through abstraction and aggregation of process activity units into different process segments types. Individual process activities or decisions are represented as *process elements* (PEs) whereas *process stages* (PSs) are collections of PEs that have the same execution frequency and a common objective. Analyzing cognitively-enhanced business processes requires identifying points in the BPA where CBA are integrated into business processes. Introducing a change at these points may necessitate supporting related changes in and around the containing business process, as well as introducing changes in the supporting process for the CBA. Fig. 1 shows a process architecture model for the loan approval domain and emphasizes the relationships between the various process elements, stages, and phases by superimposing applicable and relevant associations, primitives and patterns. A more detailed explanation of the model can be found in [1].

For reasons mentioned previously, we use i* strategic actor models to complement and extend the process architecture model by allowing the inclusion of social and agent relationships. Thus, i* diagrams can be used to determine if the design and integration of the cognitive business agent (modeled as an actor) needs to be changed based on the corresponding reconfigurations of the process architecture. An assessment of actor goal satisfaction (resulting from process reconfigurations) can be done by including enterprise NFRs in the agent model. A common fundamental element in both perspectives is that of the process activity unit, represented as a process element in the BPA model and a task in the i* model. This construct is used for connecting the two frameworks. Additionally, process stages exist to achieve some enterprise functional goals, the attainment of which can be associated with some actor.

We illustrate how the i* framework can help with analyzing and selecting viable process architecture configurations by considering as-is and to-be scenarios. For the as-is, consider the situation where no cognitive technology capability currently exists in the enterprise. Human decision-making is supported by non-cognitive enterprise systems in a business process. Fig. 1 shows an i* SR diagram with multiple actors, their dependencies and internal rationales. The **Loans Department** has certain high-level enterprise soft-goals, which are to be fulfilled by the **Human Agent**, which is playing the role of the **Loan Reviewer**. Due to the limits of human cognitive and physical abilities, the satisficing of the department softgoals (such as **Efficiency**, **Speed**, and **Consistency** of cognitive decision-making) may not be entirely ensured. However, certain personal goals of the **Human Agent** may be served through such an arrangement. For the to-be situation, the shift towards the goal of minimizing human involvement in making cognitive decisions results in the introduction of the **Cognitive Business Agent** and causes it to become increasingly autonomous and enables it to make decisions without human assistance. Fig. 2 shows an autonomous **Cognitive Business Agent** which has taken over the role of the **Loan Reviewer**, including the various activities that are performed by that role.

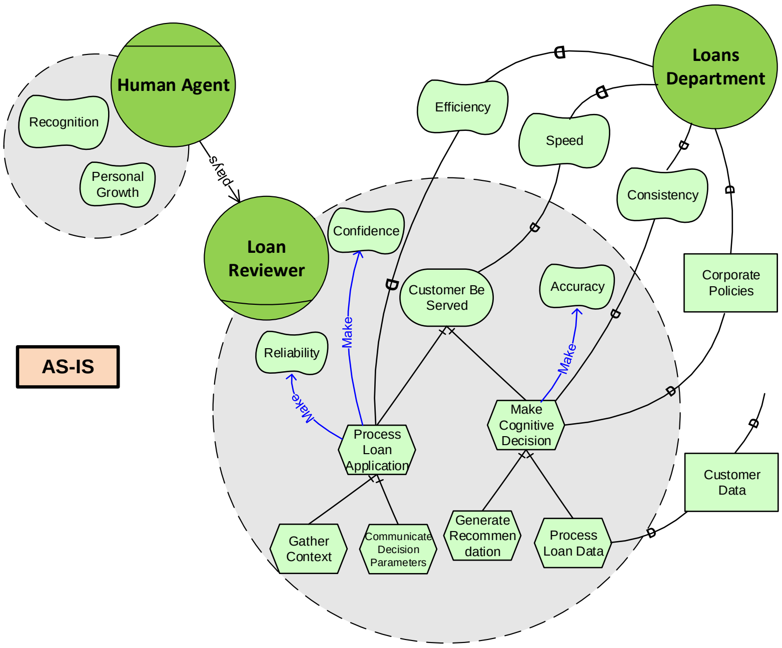

Fig. 2. As-Is i* SR diagram with no Cognitive Business Agent

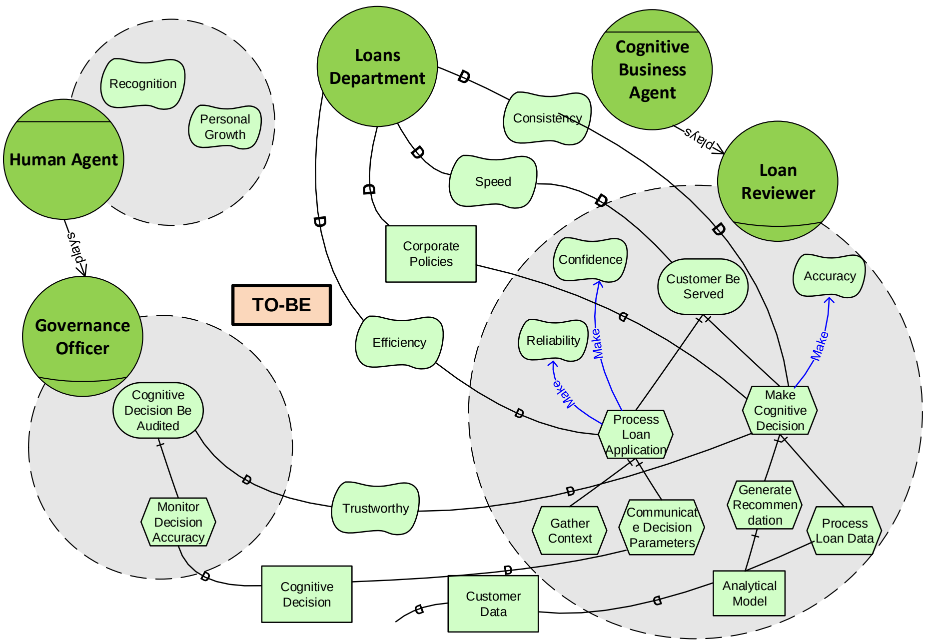

Fig. 3. To-Be i* SR diagram with the Cognitive Business Agent included

The increased responsibility of the cognitive agent results in a substantial change in relationships between human and cognitive agents. Such a change manifests itself in the form of changed actor goals and dependency relationships on the cognitive agents. In such an arrangement, the **Cognitive Business Agent** would be able to better ensure the attainment of **Loans Department** softgoals because of the improved cognitive decision-making and process automation. However, because of regulatory requirements or required corporate oversight, the cognitive decisions being made by the **Cognitive Business Agent** would need to be audited or monitored to ensure **Trustworthiness**. For this, changes to the actor model (shown in Fig. 2) and accompanying supporting business processes in the process architecture model (not-shown for brevity reasons) are required. In this case, the role of the **Human Agent** evolves from **Loan Reviewer**, who is responsible for execution of manual operational activities, to **Governance Officer**, in charge of more governance-related activities. The activities that these two roles are responsible for occur at different timescales and frequencies, which are better illustrated in the process architecture model through the use of different constructs.

As is apparent in this simple scenario, the introduction of the CBA has introduced considerable change in both the process architecture design, and the roles of the human agents involved; this would be typical of most real-life situations. Designing and managing user engagement can be done in one of two ways. The first approach reduces the complexity of managing user engagements by shrinking the space of UE options through a selection of certain purposefully created arrangements of user engagements. The second approach uses actor and goal models to capture functional goals, focusing on alternative ways of attaining them, with quality requirements playing the role of criteria for selecting among the options. Both these approaches are discussed in greater detail in [1].

3 Related Work

Due to process-level models general lack of ability to capture objectives, goal models have previously been used to add the modeling of intentional aspects to process models. For instance, while not using i* models and thus not focusing on the social aspects of processes, one well-known approach [5] proposes the use of goal models (i.e., goal refinement trees with softgoals) in conjunction with process models (in fact, the latter are generated from the former) to support the use of goal reasoning algorithms for selecting process configurations. There are also approaches (e.g., [6]) that link i* to process models. In our previous work [2] we utilized goal models in the context of BPAs to help the architecture configuration. To the best of our knowledge, this paper is the first to address the use of i* models at the level of BP architectures.

4 Conclusions & Future Work

In this paper, we focused on using i* to help with designing and evolving user engagement with cognitive software agents while considering trust, organizational, and decision-makers' requirements and constraints, as well as evolving user and system capabilities. Our goal is to develop a comprehensive method aimed at simplifying enterprise adoption of advanced cognitive systems by enabling the dynamic (re)configuration of user engagement with such systems based on various types of objectives. At present our research approach doesn't explicitly define how to handle cross-propagation of changes between the process architecture model and the i* models, and is an area of active study. Additionally, it is limited to analyzing localized design choices (including assessing trade-offs amongst them) for points in the process architecture where human agents engage with cognitive advisors.

Among other things, future research in this area will focus on (a) incorporating the analysis and evaluation of trust with the identification of various user engagements aimed specifically at establishing, maintaining, and increasing trust (the topic of trust in automation has long been attracting interest from the human-computer/robot interaction and human factors communities (e.g., see [7]), (b) changes in responsibility assignments among humans and automated systems while emphasizing the social and organizational impact of such changes, and (c) considering complex types of decisions and identify new sets of user engagement patterns as well as the typical transitions among these patterns for those decision types. The approach is currently being evaluated with a large industrial partner with the purpose of validating its practicality and usefulness.

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