

iContractBot: A Chatbot for Smart Contracts’ Specification and Code Generation

Ilham Qasse¹, Shailesh Mishra², Mohammad Hamdaqa^{1 3}

¹Department of Computer Science, Reykjavik University, Reykjavik, Iceland

²Department of Electrical Engineering, Indian Institute of Technology Kharagpur, Kharagpur, India

³Department of Computer and Software Engineering, Polytechnique Montreal, Montreal, Canada

¹{ilham20,mhamdaqa}@ru.is, ²mshailesh0511@iitkgp.ac.in, ³mhamdaqa@polymtl.ca

Abstract—Recently, Blockchain technology adoption has expanded to many application areas due to the evolution of smart contracts. However, developing smart contracts is non-trivial and challenging due to the lack of tools and expertise in this field. A promising solution to overcome this issue is to use Model-Driven Engineering (MDE), however, using models still involves a learning curve and might not be suitable for non-technical users. To tackle this challenge, chatbot or conversational interfaces can be used to assess the non-technical users to specify a smart contract in gradual and interactive manner.

In this paper, we propose iContractBot, a chatbot for modeling and developing smart contracts. Moreover, we investigate how to integrate iContractBot with iContractML, a domain-specific modeling language for developing smart contracts, and instantiate intention models from the chatbot. The iContractBot framework provides a domain-specific language (DSL) based on the user intention and performs model-to-text transformation to generate the smart contract code. A smart contract use case is presented to demonstrate how iContractBot can be utilized for creating models and generating the deployment artifacts for smart contracts based on a simple conversation.

Index Terms—Chatbot, Smart Contracts, Blockchain, Model-Driven Engineering, Domain Specific Language, Ethereum, Hyperledger Composer

I. INTRODUCTION

Smart contracts are self-executed program codes that are hosted on a blockchain platform, to enforce agreements when conditions are met [5]. Smart contracts are considered a great advancement for blockchain technology, as it enabled the technology to be adopted in many fields such as finance, identity management, Internet of Things, etc [13]. However, developing smart contract code is challenging especially for non-technical users [4], [13], as it requires one to understand (i) the language used to code the smart contract, (ii) the infrastructure constraints and limitations, and (iii) the relationships between the deployed artifacts and the resources.

Model-Driven Engineering (MDE) is one of the popular approaches used to address smart contract development challenges [3], [9], [11]. MDE is a software development methodology where models are used as first class entities for software development. Models are constructed representing distinct perspectives on a software system. They may be refined, developed into a new version, and can be applied to create executable code. The main goal is to elevate the extent of abstraction and to broaden and evolve complex software program structures utilizing models only.

In previous work [3], we proposed iContractML, a graphical modeling framework to develop and generate smart contracts code. While graphical interaction mechanisms are famous and widely accepted, some users may lack the technical abilities required to use them [6]. Moreover, using MDE requires a steep learning curve and might be challenging for non-technical users who are not familiar with modeling tools or DSLs [1], [10]. Chatbot is a promising solution to tackle this issue, where it can be utilized to facilitate non-technical users to use MDE and to enhance usability and user experience [7], [12].

In this paper, we explore the use of chatbots to develop and model smart contracts instead of the graphical interface used in iContractML [3]. The main contribution of this paper is :

- Integrate the chatbot application with the model-driven based framework iContractML.
- iContractBot: a goal-oriented chatbot application to allow users (technical or non-technical) to develop their smart contract in a gradual and interactive manner.

The rest of this paper is organized as follows: Section II describes the system design of iContractBot. The implementation of iContractBot is presented in Section III. Finally, Section IV concludes the paper.

II. ICONTRACTBOT SYSTEM DESIGN

The main goal of this paper is to create a conversational agent for model specification, where we have the conversation with the smart contract developer as an input and model specification as output. We aim to provide a link between the natural language conversation and modelling specifications, which includes capturing and extracting modeller intent, mapping the intention to modeling actions, and validating the model.

A. Modeller Intention Detection

Any goal-oriented conversational framework requires an intent recognition component to understand the user’s goal or objective. The bot must classify the end-user’s utterance into one of the predefined intents. There are many chatbot frameworks available to build conversational bots and to detect intents, such as Google Dialogflow ¹, IBM Watson Assistant

¹<https://dialogflow.cloud.google.com>

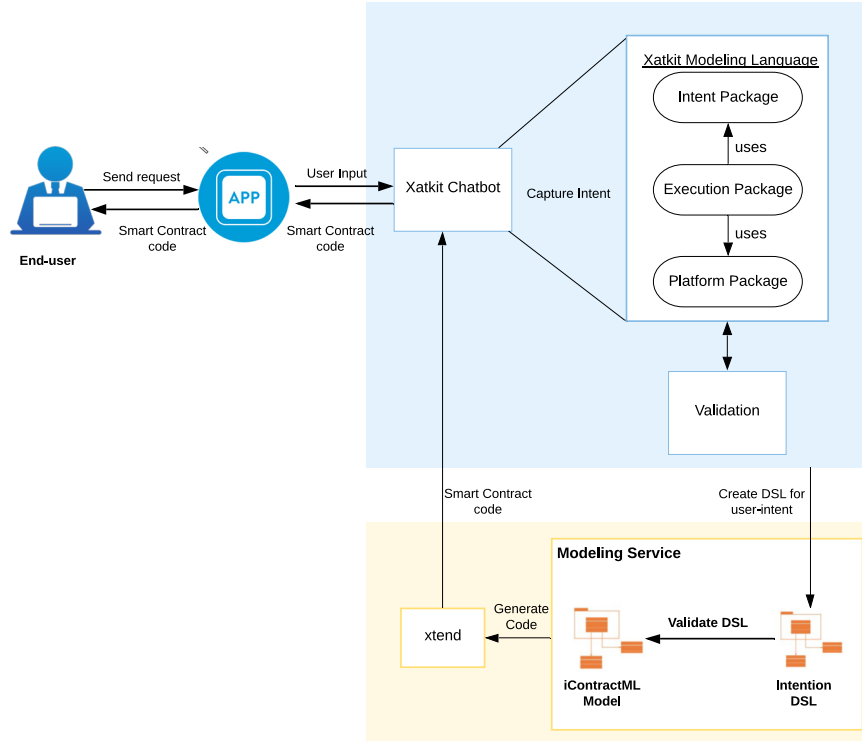


Fig. 1. iContractBot system architecture

², etc. Xatkit [2] is an open-source framework that supports integration with the previously mentioned platforms to capture user intent and understand advanced natural language. Moreover, this framework empowers building platform-independent chatbots [2]. Hence, in this paper, we have adopted the Xatkit bot framework to build the conversational bot, and to detect the user input. The user intent is detected based on a predefined set of expressions.

B. Modeller Intention to Modelling Specification Mapping

To link natural language conversation and modeling specifications, we need to map the detected user intent to the model specification (iContractML). In order to provide this link, there is a need to identify the principal entities of the model specification and represent it as a key structure for mapping it to the captured user intent. A DSL model is created based on the mapping of the user intent and the structure of the model specification.

C. Model Validation

In MDE, data validation is important because it guarantees that the system runs on valid and meaningful data [8]. The entire model-based development process can be faulty due to a single inaccurate input data. In this paper, we are performing input sanitation at the chatbot level and output validation for the created DSL, before any model transformation. This facilitates the data validation process as a chatbot is an open input

environment that is more flexible to validate, unlike MDE environments. We validate the detected user intention from any contextual errors or missing data based on the defined structure of the DSL model. This validation is done based on predefined rules that will enable the chatbot to handle incomplete or inconsistent elements (e.g., missing relationships) defined by the user.

III. ICONTRACTBOT IMPLEMENTATION

In our previous work [3], we have created a unified reference model for smart contracts. Moreover, we proposed iContractML which is a graphical framework to develop smart contracts onto multiple blockchain platforms. iContractBot integrates with the reference model of iContractML to generate smart contracts code through the chatbot framework instead of the graphical interface. iContractBot integrates different tools, including Xatkit bot framework [2], Xtext ³, and Xtend ⁴. Figure 1 demonstrates the main components of the iContractBot, which are :

- Xatkit chatbot: a chatbot framework we used to implement the conversational bot and to capture the user intent. The user intent is the smart contract description provided by the end-user.
- Validation entity: validates the captured user intent against a set of predefined validation rules, and notifies the end-user if any extra details are required.

²<https://www.ibm.com/cloud/watson-assistant>

³<https://www.eclipse.org/Xtext/>

⁴<https://www.eclipse.org/xtend/>

- Modeling Service: consists of an iContractML model and a generated DSL file based on the user intent.
- Xtend: used to generate the smart contract code based on the selected blockchain platform.

A. Preliminaries and Running Example

Using iContractBot, we have created models and generated the deployment artifacts for a vehicle auction use case. In this use case, a smart contract is used to auction vehicles, where the vehicle is the key asset. There are two participants in this example: owner and bidder. The smart contract is created by the owner to auction his/her vehicle. The bidder can place bids on the vehicles that they are interested in.

B. Chatbot Framework

Xatkit is an open-source framework to easily build platform-independent chatbots. We have used this framework to develop a web-based conversational bot and to capture the user intent. The user intent represents the smart contract use case that the end-user is interested to generate. The chat flow in the bot is directed based on the main components of the reference model of the smart contract [3]. Once the end-user finalizes the smart contract use case, iContractBot will validate the captured user intent. If there are any missing required details or errors in the user request, the bot will notify the end-user. A sample of the conversation to build the vehicle auction use case is illustrated in Figure 2.

C. Modeling Service

The modeling service represents the linking of the user intention to the modeling specification of iContractML. We first identified the key classes of iContractML meta-model and create a DSL model (illustrated in Figure 3) that acts as a structure for mapping and validating. The created DSL model is as follows:

- Contract: where the user specifies a name for the contract and a platform. We support three blockchain platforms, which are Azure, Hyperledger Fabric, and Ethereum.
- Participant: the user can specify multiple participants, where each participant has a name (or identifier), and a list of parameters that describe the participant.
- Asset: a tangible or intangible value that the user can specify. Any object of value in the real world may be represented as an asset.
- Transaction: a user will specify a transaction, which is a function that can modify the values of the attributes of a participant or an asset.
- Relationship: a user will define if the transaction has a relationship with a participant (TranRel) or with an asset (AssetRel).
- Condition: the end-user will specify if there any access condition on a defined transaction.

After the chatbot framework detects the modeler intent, we map it to the structure of the model specification and create an instance of the DSL model.

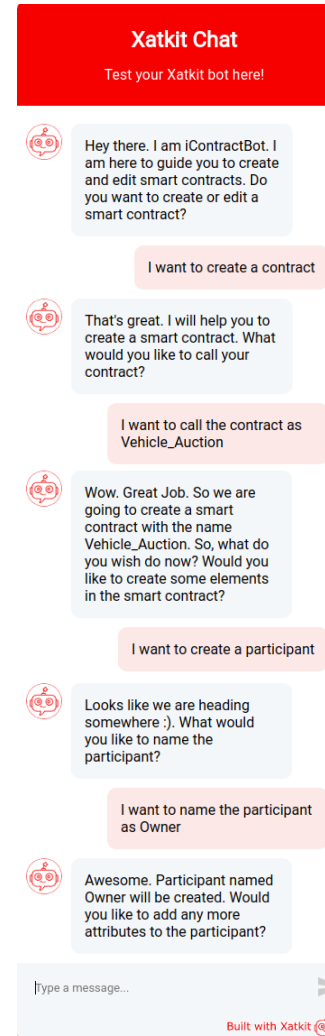


Fig. 2. Vehicle Auction Use Case Example

TABLE I
MAPPING THE INTENTION DSL CLASSES WITH VEHICLE AUCTION USE-CASE

DSL Intention Class	Vehicle Auction Use-Case
Contract	name: Vehicle Auction platform: Ethereum
Asset	name: Vehicle
Participants	Participant 1: name: Owner creator : True
	Participant 2: name: Bidder creator : False
Transactions	Transaction 1: name: Place-bid
	Transaction 2: name: Withdraw
Relationship	TranRel for Place-bid transaction: participant : Bidder
	TranRel for Withdraw transaction: participant : Owner

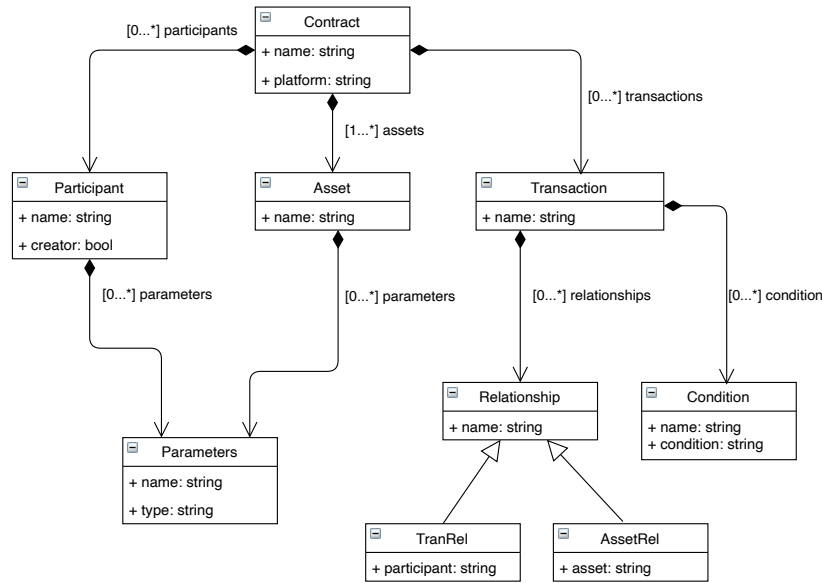


Fig. 3. Intention DSL

Table I demonstrates the mapping between the vehicle auction use case and the main classes of the intention DSL.

The DSL model instance is validated against the iContractML model. From the validated model we apply a model to text transformation using Xtend to generate the smart contract code. The transformation template used in Xtend is described in [3].

IV. CONCLUSION

In this paper, we have investigated how chatbot is utilized to facilitate the usage of MDE in code development. We have introduced iContractBot, a chatbot framework for smart contract development, and we have integrated it with iContractML, a DSML for developing smart contracts. This is achieved by building a DSL for the captured user intent and then generating an instance of the iContractML model based on the DSL by applying Model-to-Model transformation. A vehicle auction smart contract was developed using iContractBot as a case study to demonstrate the framework.

For future direction, we are planning to conduct an empirical study from multiple perspectives (user, contract language, etc.) that compares the two modalities, that is the graphical and the conversational interface.

DATA AVAILABILITY

The iContractBot project scripts are openly available at iContractBot repository⁵.

REFERENCES

[1] Antonio Bucchiarone, Jordi Cabot, Richard F Paige, and Alfonso Pierantonio. Grand challenges in model-driven engineering: an analysis of the state of the research. *Software and Systems Modeling*, 19(1):5–13, 2020.

[2] Gwendal Daniel, Jordi Cabot, Laurent Deruelle, and Mustapha Derras. Xatkit: a multimodal low-code chatbot development framework. *IEEE Access*, 8:15332–15346, 2020.

[3] Mohammad Hamdaqa, Lucas Alberto Pineda Metz, and Ilham Qasse. icontractml: A domain-specific language for modeling and deploying smart contracts onto multiple blockchain platforms. In *Proceedings of the 12th System Analysis and Modelling Conference*, pages 34–43, 2020.

[4] Tharaka Hewa, Mika Ylianttila, and Madhusanka Liyanage. Survey on blockchain based smart contracts: applications, opportunities and challenges. *Journal of Network and Computer Applications*, page 102857, 2020.

[5] Merit Kolvart, Margus Poola, and Addi Rull. Smart contracts. In *The Future of Law and echnologies*, pages 133–147. Springer, 2016.

[6] Sara Pérez-Soler, Mario González-Jiménez, Esther Guerra, and Juan de Lara. Towards conversational syntax for domain-specific languages using chatbots. *J. Object Technol.*, 18(2):5–1, 2019.

[7] Sara Pérez-Soler, Esther Guerra, and Juan de Lara. Flexible modelling using conversational agents. In *2019 ACM/IEEE 22nd International Conference on Model Driven Engineering Languages and Systems Companion (MODELS-C)*, pages 478–482. IEEE, 2019.

[8] Alessandro Rossini, Adrian Rutle, Khalid A Mughal, Yngve Lamo, and Uwe Wolter. A formal approach to data validation constraints in mde. *Proceedings of TTSS*, pages 65–76, 2011.

[9] Henry Syahputra and Hans Weigand. The development of smart contracts for heterogeneous blockchains. In *Enterprise Interoperability VIII*, pages 229–238. Springer, 2019.

[10] Juha-Pekka Tolvanen and Steven Kelly. Model-driven development challenges and solutions: Experiences with domain-specific modelling in industry. In *2016 4th International Conference on Model-Driven Engineering and Software Development (MODELSWARD)*, pages 711–719. IEEE, 2016.

[11] An Binh Tran, Qinghua Lu, and Ingo Weber. Lorikeet: A model-driven engineering tool for blockchain-based business process execution and asset management. In *BPM (Dissertation/Demos/Industry)*, pages 56–60, 2018.

[12] Stefano Valtolina, Barbara Rita Barricelli, and Serena Di Gaetano. Communicability of traditional interfaces vs chatbots in healthcare and smart home domains. *Behaviour & Information Technology*, 39(1):108–132, 2020.

[13] Zibin Zheng, Shaoan Xie, Hong-Ning Dai, Weili Chen, Xiangping Chen, Jian Weng, and Muhammad Imran. An overview on smart contracts: Challenges, advances and platforms. *Future Generation Computer Systems*, 105:475–491, 2020.

⁵<https://zenodo.org/record/4595966>