Decision Support System for Cryptocurrency

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Abstract

In the current tools related to cryptocurrency trading, there is a lack of a comprehensive decision support system(DSS) to provide traders with convenient data-based decision support. This paper gives a web-based DSS for cryptocurrency transactions that integrate market data analysis and prediction models. This system keeps a human-in-the-loop mind to make the human can interact with the system easily. The DSS aims to bridge the gap between market information and decision-making processes, providing traders with comprehensive tools to make informed investment decisions. By combining historical market data, machine learning-based price trend predictions, and user-friendly visualization, the DSS seeks to empower traders in the cryptocurrency market. Finally, we hope to build a robust and user-friendly DSS that significantly improves traders' decision-making abilities, leading to more successful and profitable cryptocurrency investments.

1 Ethics Statement

I have discussed ethics with my supervisor and there is no ethics approval required.

2 Project Plan

Today, cryptocurrency has become a recognized investment product (White et al., 2020). The word cryptocurrency refers to virtual money that has no physical form based on blockchain technology, which means that the transaction currency is invisible and secure. There are various types of this digital currency such as Bitcoin, Ethereum, Solana, DogeCoin, etc. Although it has no physical form, this currency functions in the same way as a general traditional currency, such as representing the value of commodities and used for transactions, and has an exchange rate.(Amsyar et al., 2020). Today, the most important role of cryptocurrencies, in reality, is as an investment product. The trading of cryptocurrencies is also an important part of the investment field. Some believe investing in cryptocurrencies can be an alternative to buying gold(Zohuri et al., 2022). It can be seen that cryptocurrency is one of the important assets for personal or business investment.

To trade crypto assets, people choose centralized exchanges such as Binance (Patashkova et al., 2021) or decentralized p2p trading platforms such as Uniswap (Adams et al., 2021). Cryptocurrency traders generally have their own set of trading strategies based on historical market data. Cryptocurrency exchanges such as Binance, or cryptocurrency information integration platforms such as CoinMarketCap generally provide cryptocurrency market information similar to that of a stock in the stock market, such as historical prices, trading volume, etc. But if we want to make detailed investment decisions in the cryptocurrency market, we need to further analyze market information, and even use machine learning to predict price trends.

At present, there is a lack of a comprehensive decision support tool in the market, which integrates the original market data and the analysis results based on market data to help traders in trading decisions. Based on the above reasons, I will develop a decision support system to assist investment decisions in the field of cryptocurrency to fill the gap in this field. The goals of developing this software are:

1. User-friendly operation interface and interaction functions.
2. Both novices and experts can use it.
3. Provide historical data queries, data filters, and some data analysis functions in the crypto market.
4. Provide the function of predicting the future crypto market.

A decision support system (DSS) is defined as an interactive computer-based information system designed to support the solution of decision-making problems (Gorry and Scott Morton, 1971). Organizational decision theory research by Carnegie Mellon University's School of Technology and Engineering in the late 1950s and early 1960s and MIT's research on interactive computer systems in the 1960s formed the basis for the original decision support systems (Gerrity, 1979). The earliest concept of the decision support system was proposed by Gorry and Scott Morton in the 1970s (Gorry and Scott Morton, 1971), and flourished in the 1980s and formed a certain system.

The decision support system in this paper will be built with Web technology. With the development of time and the popularity of the Internet, browsers have become the primary choice for people to surf the Internet. Web-based decision support systems are also being continuously developed. So far, the web-based decision support system has become an advanced, convenient and reliable decision-making tool (Dastres and Soori, 2021). Therefore I will develop the DSS based on the Web.

Regarding the detailed functions for this DSS, According to Robert W. Blanning's paper, we can conclude some basic functions this system needed: Select the data from the database. Perform data statistics according to the selected data, and carry out totals, averages, frequency distributions, etc. Based on historical data in the market, simulate future price movements. (Blanning, 1979) Graphical visualization is also an important part of the DSS. Graph visualization can bring a good visual experience to users. Moreover, This DSS will attach great importance to human-in-the-loop ideas. Because good human-computer interaction is the basis for bringing users a better experience. Appropriate human-computer interaction functions allow users to easily obtain the information they need so that they can make better decisions.

To develop this DSS, I arranged the following development steps, including investigation, design, development, and testing. The first part is to conduct a technical survey and select the appropriate technical framework as the front-end and back-end of the DSS. Here I choose Nodejs as the back-end development language, and use the Koajs network library to build the back-end server.(Omole, 2018) For the front end, I chose Reactjs (Aggarwal and others, 2018) as the development language and combined it with Chartjs (Da Rocha, 2019) to complete the graphics visualization work. In addition, I will try to integrate the prediction algorithm of cryptocurrency raised by Dolatsara in the back end (Dolatsara et al., 2022), so as to realize the function of simulating the price trend of cryptocurrency. The second part is design, which includes architectural design and UI design. In this part, the front-end and back-end project structure, modularization, data flow, and the way of front-end and back-end communication will be described in detail. And I will use the prototyping tool to draw the prototype of the UI, so as to provide interface reference for the subsequent front-end development. The third part is development work. In this part, I will elaborate on the specific process of development and how to use the selected development framework to achieve the functions we need. As we all know, software development will not be smooth sailing. In this part, I will describe the valuable problems encountered in the DSS development process and the solutions to these problems. The last part of the development is the test of DSS. For the test of DSS, I will include two solutions, the first is to use test scripts for automated testing, and the second is to personally act as a user to test actual usage scenarios. For automated testing using test scripts, it also includes divisions such as unit testing and integration testing. Unit testing requires our project to have a good modular structure, so that each function or module can be executed independently.(Leitner et al., 2007) Integration testing is based on unit testing, to test whether all the software units are assembled into modules, subsystems or systems according to the requirements of the outline design specifications, and whether the work of each part meets or realizes the corresponding technical indicators and requirements (Brar and Kaur, 2015). For the actual use experience test, I will preset some usage scenarios, and then use this DSS to try to achieve the goals that users want to achieve in these usage scenarios.

Finally, I will give a complete introduction to the software after it is all implemented. And evaluate the DSS that has been completed, and use the scoring method proposed by Louis (Blanc and Jelassi, 1989) to score the DSS. Next, refer to the scores of other software in the industry that use this method to give a relatively objective evaluation.

This paper is structured as follows: The Introduction is the first section, which will talk about the background of cryptocurrency and DSS and why this DSS is needed. The second section is Literature Review. In this section, I will give an initial survey of relevant implementation and literature about cryptocurrency trading and DSS. The third section is Methodology. The methodology chapter will describe the approach and methods used to develop the hybrid decision support system. It will outline the software development process, including requirements gathering, system design, implementation, and testing. The chapter will also discuss the selection of data APIs and graphical visualization frameworks to be utilized in the system. After that is the Design and Implementation section. This section will present the detailed design of the decision support system, including the architecture, data flow, and user interface. It will describe the implementation process, highlighting the utilization of programming languages, libraries, and frameworks. The chapter will also address challenges faced during development and the solutions adopted. The Result is the fifth section. In this section, I will show the final UI and the complete workflow of this decision support system. This section will give a mark by professional evaluation method for this DSS. The Case Application section is the sixth section. I will discuss some real-world examples to illustrate the usability and practicality of this decision support system in this part. The last section is the Conclusion. The final section will summarize the entire project, highlighting the key contributions, achievements, and conclusions. It will also discuss the implications of this DSS and its potential impact on the field of cryptocurrency investment. The chapter will conclude with suggestions for future work and enhancements to the decision support system.

3 Literature review

This section will talk about the investigation of relevant literature for this paper. Because the DSS implemented in this paper is in the cryptocurrency investment field, focuses on human-in-the-loop, utilized Web technology, and combines multiple testing scenarios, the papers I surveyed will cover all of these areas.

3.1 Decision Support System (DSS)

Regarding papers about decision support systems, I'd like to organize the history of it and how it developed. As the last section mentioned, the prototype of the decision support system began to develop in the late 1950s and the early 1960s (Gerrity, 1979). Gorry and Scott Morton formally proposed the name Decision Support System in the 1970s (Gorry and Scott Morton, 1971). In this period, Blanning said that a DSS can assist people in making unstructured or partially structured decisions in which judgmental issues are paramount.(Blanning, 1979) He also raised 6 basic functions of DSS:

1. Data selection from the database.
2. Calculation and aggregation of data into totals, averages, frequency distributions, etc.
3. Estimation of the parameters in a probability distribution.
4. Simulation to calculate the anticipated consequences of proposed decisions and/or of possible changes in the corporate environment.
5. Equalization to calculate decisions whose consequences will meet certain consistency conditions.
6. Optimization to determine decisions that will maximize or minimize a single measure of performance or cost without violating constraints on other such measures.

The first function of DSS emphasizes the acquisition filtering and extraction of data. The second and third functions of DSS emphasize the statistical analysis and aggregation of the data. The fourth function of DSS indicates prediction and simulation with mathematical methods from the existing data. The fifth and sixth functions of DSS show that the given decision from DSS should follow certain boundaries and constraints. It is important in some fields such as repository management, transportation management, etc. For the cryptocurrency investment area, it means the decision given by DSS should not violate some income or risk-return rate model. Although this article was published in an earlier era, these basic functions still guide the design of modern decision support systems.

After that, with the radical research on decision support systems, decision support systems are also widely developed.(Alter, 1980) At this time, the decision support system has begun to form the basic mode of human-computer interaction. Because the decision support system does not have the ability to solve specific problems alone, but provides assistance for human decision-making. In other words, the decision support system solves the structured, data and data-related problems it is good at, and humans are responsible for the unstructured part of the complex inference decision. The purpose of developing a decision support system is to improve the efficiency of decision-makers in making decisions (Arnott and Pervan, 2005). As well, D. Arnott concluded the different types of DSS in his paper, which include personal decision support systems (PDSS), group support systems (GSS), intelligent decision support systems (IDSS), executive information systems (EIS), negotiation support systems (NSS), data warehousing (DW), and knowledge management-based DSS (KMDSS). These different types of DSS appear one by one in chronological order, and the emergence of each new DSS is closely related to the emerging technology at that time and the generation of new needs with social development. According to the description of these types of DSS, the DSS raised in this paper should be an AI participated PDSS. AI in this system is not dominant, which just provides technical support for the prediction of price trends. And this system is for personal users to make decisions for their cryptocurrency trading actions.

How to build a DSS is also a problem for the developer. To get some inspiration, we can consider the 5 steps for solving a decision problem raised by Turban (Turban, 1990)(Dastres and Soori, 2021):

1. Properly define the problem or consider the chance of it happening.

2. Build models or DSS or other alternatives.

3. Check all options, select one after evaluation.

4. Put the solution of your choice into action and implement it.

5. Finally review our decision-making solution and re-evaluate it.

These few steps are the source of inspiration for me to consider the development order of the DSS for the field of cryptocurrency investment. For example, we define the problem to be solved as trading in the cryptocurrency market and earning a profit. It is further divided into several actions such as currency selection, buying time, buying quantity, selling time, and selling quantity (leverage trading is not considered in the decision-making system). Next, model the problem. Setting the above several actions as variables, we can get the expression of income. Then try to select the optimal action behavior, which should be selected according to the future price trend predicted by machine learning. Then we make actual investments in the virtual currency trading market. Finally, review the effectiveness of our decisions in terms of actual returns.

In order to make this DSS have a better user experience, I hope that human in the loop is an important feature of DSS. Human in the loop (HiTL) is introduced in the paper 'A survey on Human-in-the-Loop applications towards an Internet of All' by Nunes, that is, humans provide information to the system, and the system makes inferences or certain predictions based on the information provided by humans. The behavior of the system can also affect humans. In this way, a cycle between humans and the system is formed.(Nunes et al., 2015) To implement the HiTL mechanism into the DSS, I should consider the data flow in the DSS. The DSS should receive some data from humans, such as current currency, risk aversion, and market information. Then it will analyze the given data, and induce some advice for cryptocurrency investment. When people do the trading, their currency will change and the market will change too, even if a light change. That is a loop, and we can call it HiTL.

The other important point for DSS in this paper is that it uses Web technology. In 2007 there is a literature review paper to tell the progress in Web-based decision support systems (Bhargava et al., 2007). The paper said, the Web-based DSS technology is raised in 1995, at the 3rd International Conference of the International Society for Decision Support Systems (ISDSS) in Hong Kong. There are numerous ongoing attempts to create and deploy Web-based DSS across a variety of sectors as a result of the increased interest in the Web. There are many academic papers on Web-based DSS that are largely focused on the implementations of the applications. In the article, the author discusses several architectures of web-based DSS. Due to the development of Web technology at that time, DSS can be implemented flexibly in different architectures. For example, databases, documents, and computing resources can be stored on a single server, or stored on different servers for on-demand access. Of course, these architectures in 2007 seem outdated today, but we can still see from them that there was a wide variety of Web-based DSS at that time. A recent literature review on Web-based DSS is shown by Dastres in 2021.(Dastres and Soori, 2021) This study focuses on the latest research results and applications of Web-based DDS internationally. This study focuses on the latest research results and applications of Web-based DDS at home and abroad. It also introduces some advantages of Web-based DSS, such as fast and cheap access to global knowledge and data information, and convenient cooperation with remote partners. In addition, convenient development, simple deployment, and easy access are also the advantages of web-based technology.

3.2 Web Development

At present, there is a relatively mature process for project development based on the Web. First, we need to choose the loading mode of the project. There are two commonly used modes, front-end separation or server-side rendering (Gong et al., 2020). In a project where the front and back ends are separated, when the browser accesses the server address, it will first obtain a packaged JavaScript script and some CSS

files. The display of the view, that is, the content of the HTML file will be generated by JavaScript script. In addition, in the mode where front-end and back-end are separated, the front-end display generally needs to use some data from other interfaces, and these interfaces are not deployed in the same server. Due to the characteristics of the framework that separates the front and back ends, this mode is very friendly to asynchronous loading. When the front end obtains the data it needs from the interface, the data will be updated on the view immediately. Another method is server-side rendering, that is, the server directly records all the content that needs to be displayed on the front-end in the HTML file as much as possible. Generally, content rendered asynchronously will not be included. Of course, this does not mean that server-side rendering does not support asynchronous operations. We can still update the view in a timely manner when the page receives some interface responses through JavaScript scripts. Compared with client-side rendering, server-side rendering is more SEO-friendly and less blocking rendering, and it will perform better in some scenarios. The client-side rendering will have a better first frame drawing time and faster interaction speed.(Iskandar et al., 2020)

Since the DSS needs to obtain cryptocurrency market data from a third-party interface, it has relatively high performance requirements for asynchronous operations, so I choose the client-side rendering mode. After determining the rendering mode, I began to choose the front-end and back-end development languages and frameworks. Front-end development languages are basically JavaScript combined with HTML and CSS, but there are many types of development frameworks, such as React (Rawat and Mahajan, 2020), Vue (Rojas, 2019), Jquery, BootStrap, etc. And the web backend can be implemented in multiple languages, such as C++, Golang, Rust, Python, or Nodejs (Kaluža et al., 2019). I selected React as my front-end development language because of its extensive community support and rich third-party library. And I choose Chartjs as the framework for data visualization. Because Chartjs is easy to use and can provide beautiful visual charts(Da Rocha, 2019). In addition, there is no conflict when Chartjs and Reactjs are used together, and they can exist harmoniously in a front-end project. For the choice of the backend language, I tend to use Nodejs for development. As an interpreted programming language, Nodejs has the disadvantage of slower execution speed compared to other compiled programming languages. But the advantage of using Nodejs as back-end development is that we can use JavaScript to develop both front-end and back-end at the same time, which greatly reduces learning costs and improves our development efficiency.(Brown, 2019) Furthermore, there are some well-received web server libraries available to us in the Nodejs community, one of which is easy to use is Express.js, which library I will use to develop a web server. Finally, regarding the interaction between the front-end and server side, we can use the RESTful API to do it (Wang et al., 2014). REST is a set of architectural constraints, but not a protocol or a standard. API developers can implement API which satisfied REST constraints in a variety of ways. For example, a set of APIs meets the following requirements: use the GET method to obtain data, use the POST method to add data, use the UPDATE method to update data, and use the DELETE method to delete data. Such a set of APIs satisfies the definition of a RESTful API.(Biehl, 2016)

3.3 Crpytocurrency Investment

Now let's turn our attention to cryptocurrency investing. Since the DSS we want to implement is aimed at customers in the field of cryptocurrency investment, we need to understand some literature in this area in order to design and implement the core functions of DSS. Without the aid of intermediaries like banks or governments, cryptocurrencies can be used as an investment good with value.(Zohuri et al., 2022) The first and most popular cryptocurrency is Bitcoin, which was introduced by Satoshi Nakamoto in 2008 (Nakamoto, 2008). Since then, thousands of other cryptocurrencies have emerged, such as Ethereum, Solana, DogeCoin, ShibaCoin, etc.

What influences investor behaviour and decision-making is one of the key research concerns in bitcoin investment. I will explore the factors that influence cryptocurrency investment decisions and the benefits and risks of cryptocurrency investment. One of the factors that influence cryptocurrency investment decisions is investor behavior. Almeida concluded that there is obviously herding behaviour in the cryptocurrency market. The crypto market is dominated by irrational investors who base their

investment decisions on market sentiment; the uncertainty of the market movement leads to investors' dispersed beliefs, which in turn leads to high trading and speculative bubbles (Almeida and Gonçalves, 2023). Another paper wroten by Almeida said that another factor that influences cryptocurrency investment decisions is volatility and risk management (Almeida and Gonçalves, 2022). There are a lot of methodologies that can simulate cryptocurrencies' volatility and manage the risks associated with them. The author found that the best machine learning technique to handle risk management is hybrid models such as support vector machines. A third factor that influences cryptocurrency investment decisions is the market analysis and perspectives published by agencies or governments (Giudici et al., 2019). The authors gave a literature review and analysis of the papers published from 2009 to 2019 about the cryptocurrency field. They present their findings on socioeconomic, misconduct, and sustainability issues in the cryptocurrency space. They recovered that cryptocurrencies may perform some useful functions in society and add economic value.

To ensure an efficient investment strategy in cryptocurrency, Liu introduced the three factors model to predict the movement of the market. Which are the cryptocurrency market, size, and momentum. They successfully created long-short strategies for ten tokens in cryptocurrency and produced considerable excess returns that are statistically significant. They also show that all of these strategies could be explained by the three-factor model of cryptocurrency.(Liu et al., 2022)

Dolatsara created a small DSS to predict the price of BTC for short-term investors. The author raised a comprehensive three-level feature selection method. And with selected features, the author used the Classification and Regression Tree to build a prediction model, this model is interpretable and simple to understand. Compared with other current models, this model has higher prediction accuracy and is also better than models built by other machine learning methods in terms of interpretability. So it is very suitable to use this tool to assist short-term investors in making decisions (Dolatsara et al., 2022).

For the DSS in this article, we may appropriately present users with market information that is helpful in making investment decisions according to the above research, taking into account regulation. At the same time, we can provide users with helpful external links, so that users can access external websites to obtain more sufficient market information. Moreover, we can give two forecasting models for users to choose from. The first is the three-factor model proposed by Liu, and the second is the forecasting model based on the C&RT algorithm proposed by Dolatsara. The recommender part of a decision support system makes investment recommendations to users based on these models.

3.4 Testing and Evaluation

There are two purposes for introducing test steps into the project, one is to ensure the robustness of the engineering structure and modules, and the other is to ensure the user experience. For example, Nuno concluded a black box tool to test the REST API services to make sure they can provide stable services.(Laranjeiro et al., 2021) Leitner raised a unit test method to make the test more efficient in his paper in 2007 (Leitner et al., 2007). The above test methods can help the engineering project to be more stable and ensure that the code can execute as expected. The following will introduce some user experience tests to ensure that DSS can meet user needs and bring users a pleasant user experience. For instance, Kraig Finstad defined some usability metrics for user experiences, such as efficiency, effectiveness, and satisfaction (Finstad, 2010).

Jadhav and Sonar concluded a series of evaluation methods for software packages, such as analytic hierarchy process (AHP), feature analysis, weighted average sum (WAS), and fuzzy based approach, and analyzed the advantages and disadvantages of these evaluation methods (Jadhav and Sonar, 2009). I refer to the weighted average sum methods to evaluate my DSS. The detail of WAS can be found in the paper written by Blanc and Jelassi, which included the process from selecting and filtering software to mark the score (Blanc and Jelassi, 1989). Generally, it will assign each criterion the weights and rating scales, and sum the rating to get the total score for the software. Because the evaluation is facing to the industry for rating the software, I will simplify the marking process. Finally, I will give a relatively subjective result for my DSS referring to the score of other software under this evaluation method, for example, the evaluation of workflow software (Pérez and Rojas, 2000).

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Appendix 1: Schedule of the Project

- Jul 03 - Jul 05, Design the UI, Design the architecture of the project, Design RESTful API.
- Jul 06 - Jul 12, Initial the Front-end and the Back-end project.
- Jul 12 - Jul 13, Research the Crypto public API.
- Jul 14 - Jul 17, Familiar with Chart.js
- Jul 17 - Jul 24, Show the market data on the Webpage.
- Jul 25 - Jul 27, Depoly the price prediction system on the server side.
- Jul 28 - Aug 01, Design and implement the interaction in Front-end.
- Aug 02 - Aug 03, Optimize the layout and UI view.
- Aug 04 - Aug 07, Clean and review the whole code in the project.
- Aug 08 - Aug 10, Test the DSS.
- Aug 11 - Aug 14, Deploy the DSS on AWS.
- Aug 15 - Aug 31, Complete the report and keep optimizing the DSS.

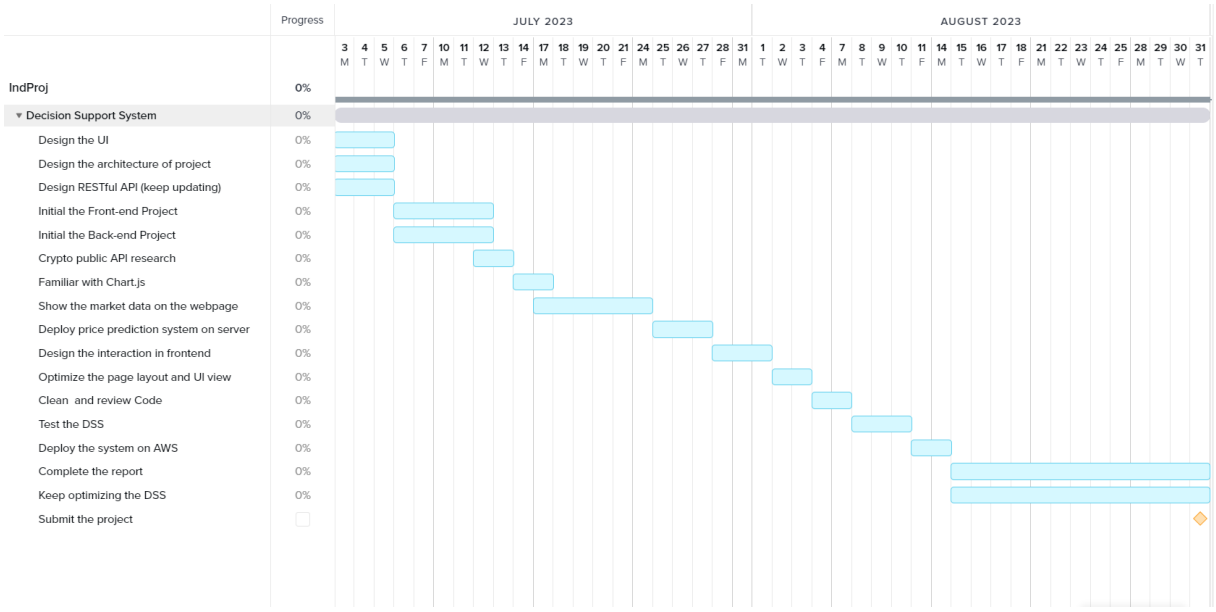

Figure 1: the Gantt Chart of Project Schedule (Created by TeamGantt)

Appendix 2: Risk Assessment

1. This is a big project with a lot of work. Likelihood: 80%. It is possible that the functions of the project cannot be fully realized, or the functions are not perfect. To reduce the risk, I can reduce the development workload of the project as much as possible in the project plan, retain the core functions, and arrange the development tasks of other functions at a level that can be completed by one person. However, the personal assessment may not be accurate enough, and development tasks need to be dynamically adjusted in the subsequent development process.

2. Deploying a cryptocurrency prediction model on the back end may be technically problematic, because some literature does not give specific codes, and some literature code languages are different from the programming language I am currently using. Likelihood: 50%. This problem may cause the development progress of the prediction module in the project to be blocked. In order to solve this problem, you can find documents with source code, and query the information to solve the problem of cross-language deployment.