Application of Tiered Technology in the Development of Computer Software

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Abstract. Software reliability is one of the critical factors to be considered in the process of system design, research and operation. Different from most current studies of software reliability modeling and simulation that are limited to simple series-parallel models, the optimization method is applied to the reliability modeling and simulation of large-scale, complex software system combined with an agrometeorological application system. The application of tiered modeling technology in system development is introduced, and the related tiered technology knowledge is elaborated.

Keywords: Tiered Technology, Modeling, Use Case, Class Diagram, Package

1. Introduction

Tiered technology is initiated by famous software technology experts G.Booch, J.Rumbaugh, and I.Jacobson [1-2]. Based on the Booch representation, OOSE method and OMT method, it is formed by integrating the advantages of many families. At the end of 1997, it was adopted by international OMG as a standard modeling language based on object technology [3-4]. It is one of the most important software technologies with epoch-making significance in the past decade. It not only supports object-oriented analysis and design [5-6], but also helps the whole process of software development starting from requirement analysis.

Tiered technology provides rich and robust models for the design and development of software systems, which can be used to describe the whole system comprehensively. But it is also very complex. For different systems in various fields, due to the differences in specific requirements and design objectives, the adoption and focus of the model are not the same. The author's laboratory has been engaged in the research and development of computer software systems in the field of Agrometeorology for a long time. This paper will discuss the modeling technology and related issues...
based on tiered technology in combination with the “drought advisory system”.

2. Basic characteristics of tiered technology modeling process

Software reliability modeling and simulation is to allocate the reliability index of the system to each component of the system reasonably, determine the quantitative requirements of the reliability of each component, to ensure the reliability index of the whole system. In this paper, the evolutionary calculation method is used to calculate the reliability of each component under the condition of minimizing the system cost with the system reliability as the constraint, Thus, the system decision-makers can allocate resources to each component reasonably. On this basis, the software reliability modeling and simulation problem is simplified to the optimization objective model based on the cost function. The objective function can be written as the function of each component reliability:

\[ \text{Min cost} = \sum_{i=1}^{n} \text{cost}(r_i) \]

\[ \text{s.t. } RE \geq RE_o, \]
\[ 0.5 < r < 1, \]
\[ RE_o = 0.9. \]  \hspace{1cm} (1)

When the constraint equation is added to the objective function as a state transition matrix term, it is turned into an unconstrained optimization problem as follows:

\[ \text{Min cost + penalty} = \sum_{i=1}^{n} \text{cost}(r_i) + k \cdot \min \left\{ 0, RE - RE_o \right\} \]  \hspace{1cm} (2)

3. Development process based on tiered technology

Tiered technology is a modeling language, not a method. A system development method is theoretically composed of modeling language and development process, which is used as the symbol of system design, and the process is used to describe the steps needed for development. The system development process based on tiered technology has different divisions from different perspectives:

(1) From the perspective of managers, each iteration of system development mainly includes the following stages:

① In the decision stage, the objectives and scope of the project are defined, the feasibility analysis is carried out, the economic benefits of the project are predicted, the project boundary is divided, and the project scale is estimated.

② In the planning stage, the detailed system analysis is carried out, the basic system structure is defined, and the detailed implementation plan is formulated.

③ In the construction stage, based on the project implementation plan developed in the above stages, the actual project development work is carried out in an iterative and incremental way.

④ The submission stage means that the system enters into the actual use stage. It mainly includes performance optimization, user training, technical support and maintenance, etc.

(2) From the perspective of technical implementation, each iteration of system development includes four stages: analysis, design, implementation and test. In these four stages, we use tiered technology to build different models to achieve different purposes.
① The first step in the requirement analysis stage is to define use cases and use case technology to establish external requirements of the system. How to specifically describe the external requirements of the system? Generally speaking, for large-scale systems, first list all the roles in the system, and then determine the use cases for each role, for small-scale systems, you can directly list the required use cases, and then determine the roles for each use case.

In use case diagrams, roles refer to people and things interacting with the system, and roles execute use cases. In this system, the main roles are: domain experts, consulting users and auxiliary personnel. On the basis of determining the use case, confirm the use case. The corresponding use cases are: knowledge base maintenance, drought consultation and data database management.

In addition to describing system requirements by use case diagrams, activity diagrams (or words) are also used to describe the requirements of each use case, to describe the interaction between the use case and the role in more detail. The activity diagram mainly illustrates workflow and behavior model including parallel processing, through which the functional analysis of use cases can be implement implemented. Figure 1 shows the requirements for describing the use case of knowledge base maintenance are described.

![Diagram](image)

**Figure1.** Requirement description of knowledge base maintenance use case

The use case diagram and activity diagram describe the system requirements in a visual way, avoiding the fuzziness of the text description, and providing a guarantee for the establishment of a correct system.

② The purpose of domain-specific analysis is to build a domain-specific model. All key concepts and their relationships can be derived from the use case diagram and activity diagram above. The specific domain classes in this system can be determined as DMC, RIMC, RRC, ROMC, and KDMC.

The class diagrams are used to describe system domain classes and their relationships.

The class diagram describes the static relationship of classes in the system. It not only shows the structure of information but also describes the behavior of the system. These classes and relationships always exist in the system. At this stage, the specific implementation of system functions is not involved. At this time, the description of specific classes (class properties and operations) is not finally defined. Some operations need to be determined in the design stage. Class diagrams describe the static relationships of classes in a system.

To describe the dynamic behavior of specific classes in the system, the sequence diagram, cooperation diagram or activity diagram of hierarchical technology can be used. Sequence diagrams indicate the interaction of objects in chronological order over their lifetime. The sequence diagram
uses two-dimensional coordinates to represent time in vertical coordinates and different objects in horizontal directions. In the “drought consulting system”, the consulting user inputs the information and necessary data to be consulted from the input management object, and the input management object judges the validity of the input information, and then transfers it to the reasoning object for processing, the reasoning object obtains the relevant data from the knowledge base and the meteorological database based on the agricultural gas data management object, and then carries out the reasoning. The results are displayed by output management objects (charts, GIS map overlay, printing, etc.). In the knowledge maintenance object, domain experts query information through the agricultural gas data management object.

Sequence diagrams are plotted based on use cases, which show how domain-specific classes (objects) jointly implement use cases. When modeling with sequence diagrams, you may find new operations that need to be added to the corresponding classes.

③ A well-designed system structure is the basis for the system to be expandable and changeable. Package technology can separate application logic from technical logic, to reduce the dependence between them (reflecting the principle of high aggregation and low coupling between modules) and help to establish an optimized system structure. A package is a higher-level unit composed of multiple class sets. It can well describe the logical components of the system and the dependency between the components. We will put the classes defined in the analysis phase into different functional packages according to their functions, in addition, we will define some new packages as required, and define the dependency and communication mechanism between packages. The following packages are included in the drought advisory system:

The purpose of the detailed design is to improve and extend the domain object class and describe the new technology class. In the detailed design stage, we use tiered technology to refine these classes. Provide information and support for users. Users and systems interact through the user interface. Supported by the visualization technology, the design of the user interface is more convenient. The main body of the system is written in VC++, and the user interface can be customized quickly by using the application framework method. The “drought consultation system” requires a large number of meteorological data and expert experience knowledge, so it must be supported by permanently stored objects (databases), and the system needs to have a database layer to provide services. We can set up a permanent storage class FMDC to implement the general operation of database, such as append, modify, retrieve, delete, etc. Other classes that implement database operations are inherited from FMDC.

The domain classes in the analysis stage are refined and improved to implement their association and behavior. In the analysis phase, the operation of a class may be decomposed into several operations or renamed in the design phase. The implementation phase is also the coding phase, we use VC ++ to write. During coding, defects in the design model may also be found, at which time the model must be modified again. Considering the need of maintenance, the consistency of design model and coding should be maintained when modifying the model.

The purpose of testing is to identify errors. The test work is based on the use case description to verify whether the system meets the requirements. The configuration of the system is the actual delivery system, including documents and component models. The relationship between the testing,
configuration and the tiered technology is shown in Figure 2.

![Figure 2. Test, configuration, and hierarchical technology diagram](image)

**4. Conclusions**

The practice has demonstrated that tiered technology is an excellent modeling language, which is suitable for the development process in all stages. In the system development, the use of tiered technology can help developers have a clear understanding of the whole system (especially large and complex application systems with unclear requirements), to establish various system models and prepare for later coding. In the development of the agrometeorological intelligent system, we established the model based on tiered technology and achieved remarkable effect. Currently, we are making further research on the component and component technology based on the tiered technology (for the agrometeorological analysis field).

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