Analysis of a crop growth model using Unified Modeling Language

Kwang Soo Kim, Do-Gyeom Kim, Sey Hyun Kim, Grim Hwang, and Haneul Jeong

Department of Plant Science, Seoul National University, Seoul, 151-921, Korea

ABSTRACT

Crop growth simulation models have been developed as research and management tools. When these models are needed to incorporate new knowledge on phenology and physiology of crops, programming languages have been used for development and documentation of these models. However, researchers may have limited skill in programming languages. Furthermore, software developer may find it challenging to improve the crop models because documentation of the models are rarely available. The Unified Modeling Language (UML) can provide a simple approach for development and documentation of model. A template for implementation of the model can be obtained using the UML, which would facilitate code re-use and model improvement.

Key words: Crop growth model, Fortran, C++, UML, Documentation, programming language

I. INTRODUCTION

Crop growth models provide many opportunities for analysis of abiotic and biotic effects on crop production. Because these models simulate crop biomass production integrating the effects of soils, weather on crop growth, they have been used to construct a decision support system for efficient crop management. For example, spatial variability of yield can be explained using a crop model (Thorp et al., 2008).

Incorporation of new model components into a crop model is often needed to improve simulation of crop growth under a specific condition. However, it is challenging to modify the crop model because most models are written in computer language with which researchers are not familiar. For example, most of crop growth models, e.g., Decision-Support System for Agrotechnology Transfer (DSSAT), World Food Studies (WOFOST) model, and ORYZA 2000, are written in Fortran, which is rarely used except in specific areas in meteorology, computational biology, and engineering.

Software developer may have difficulty in developing or improving functions of the crop model because documentation of the crop model is rarely available. Requirements and constraints of modules, subroutines, and functions in crop models are mostly described in its source code rather than in separate documentation. Thus, it is difficult to grasp overal flow of information and individual functionality of each module in the crop model.

Unified Modeling Language (UML) has been used to develop and document models as a modeling standard. Advantage of using UML is its simplicity. It provides simple diagrams needed for analysis and design of models. Our approach aims to provide a methodology for analyzing a crop growth model using UML, which can facilitate documentation of the crop model.

II. METHODOLOGY

UML has been used to develop a prototype of models, which can be easily understood by computer programmers and common researchers who have no experience in programming. Identification of common elements and description of relationship between them are major procedure in developing a crop model in UML. It is also useful to develop documentation for data input requirements and processes involved in crop growth.

Because design and structure of crop models are represented by plain text or diagrams in UML, it makes it easy to communicate between researchers and software developers. In particular, researchers who are not familiar with programming language can understand the functions and structure of the crop model. Furthermore, it is easy to convert the source code of a crop model to a new language because the model developed using UML is not subject to a specific programming language.

III. ANALYSIS

DSSAT was analyzed using diagrams provided by UML to document structure of functions of the crop model. DSSAT consists of 421 subroutines and functions, which forms a complex network between these modules. Each module also has a large number of arguments which transfer information between functions. Diagrams were used to describe such networks and argument lists (Figs 1, 2).

<<Fig. 1>>, <<Fig. 2>>

IV. DISCUSSION

It is important to maintain a crop model because new knowledge needs to be incorporated into the model. Conversion of the models to contemporary programming language, e.g., C++, would facilitate maintenance of the crop model because most software developers or even small number of researchers are familiar with such programming language. When a crop growth model written in a computer programming language, e.g., Fortran, is converted to another language, e.g., C++, it is required to analyze the structure of the model. Diagrams in UML can be used to describe data and behavior of a crop model, which forms templates for model construction. These diagrams can facilitate the development and modification of existing crop models.

REFERENCE

Thorp, K.R., K.C. DeJonge, A.L. Kaleita, W.D. Batchelor, and J.O. Paz, 2008: Methodology for the use of DSSAT models for precision agriculture decision support. *Comput. Electron. Agr.* **64**: 276-285.

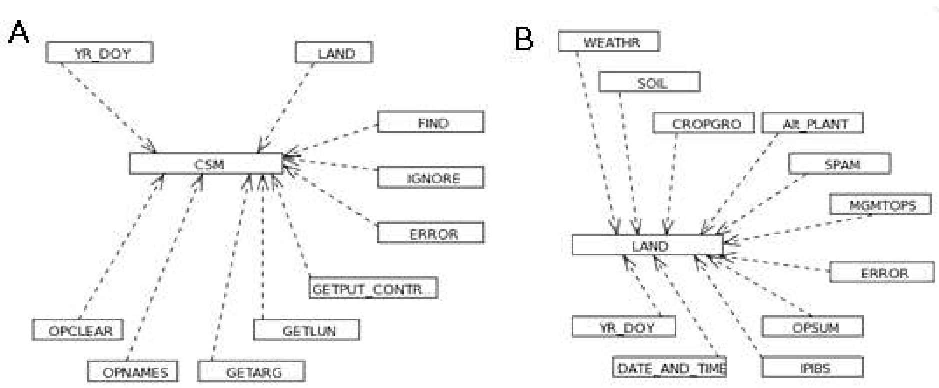

Figure 1. Diagrams of functions and subroutines associated with CSM and LAND subroutines in the Decision-Support System for Agrotechnology Transfer (DSSAT).

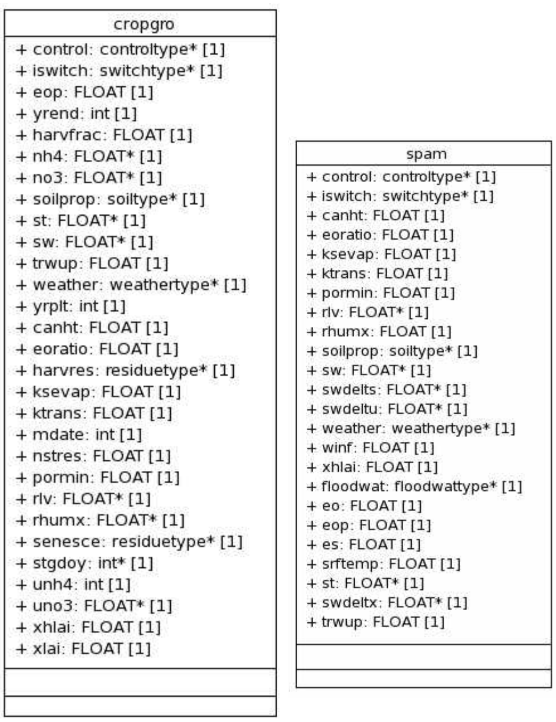

Figure 2. Diagrams that represent arguments used in CROPGRO and SPAM subroutines in the Decision-Support System for Agrotechnology Transfer (DSSAT).