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DISCRETE EVENT SIMULATION IN AN ARTIFICIAL INTELLIGENCE ENVIRONMENT: SOME EXAMPLES

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ABSTRACT

Several Los Alamos National Laboratory (LANL) object-oriented discrete-event simulation efforts have been completed during the past three years. One of these systems has been put into production and has a growing customer base. Another (started two years earlier than the first project) was completed but has not yet been used. This paper will describe these simulation projects. Factors which were pertinent to the success of the one project, and to the failure of the second project will be discussed (success will be measured as the extent to which the simulation model was used as originally intended).

PROJECT 1: THE DOE TASP[1] MODEL

Background

The United States' nuclear weapons production complex is now more than 40 years old, and the production facilities are aging. Environmental legislation now exists where none existed previously. In addition, the world political environment has changed drastically in recent years. For these reasons, as well as others (proximity of DOE facilities to major metropolitan centers), the U.S. Department of Energy is evaluating future options for reconfiguring the weapons production complex.

To assist DOE in their technology assessment process, LANL developed an object-oriented discrete-event simulation. This simulation is designed to allow the analysts to evaluate the impact of existing as well as new technologies in the various areas of possible, future, weapons production complex alternatives (e.g., Complex21). Figure 1 shows an example process layout, like those being modeled for Complex21.

Project History

The TASP modeling project actually started on September 1, 1990. A prototype of the

[1] Technology Assessment and Selection Panel

Example Process Layout

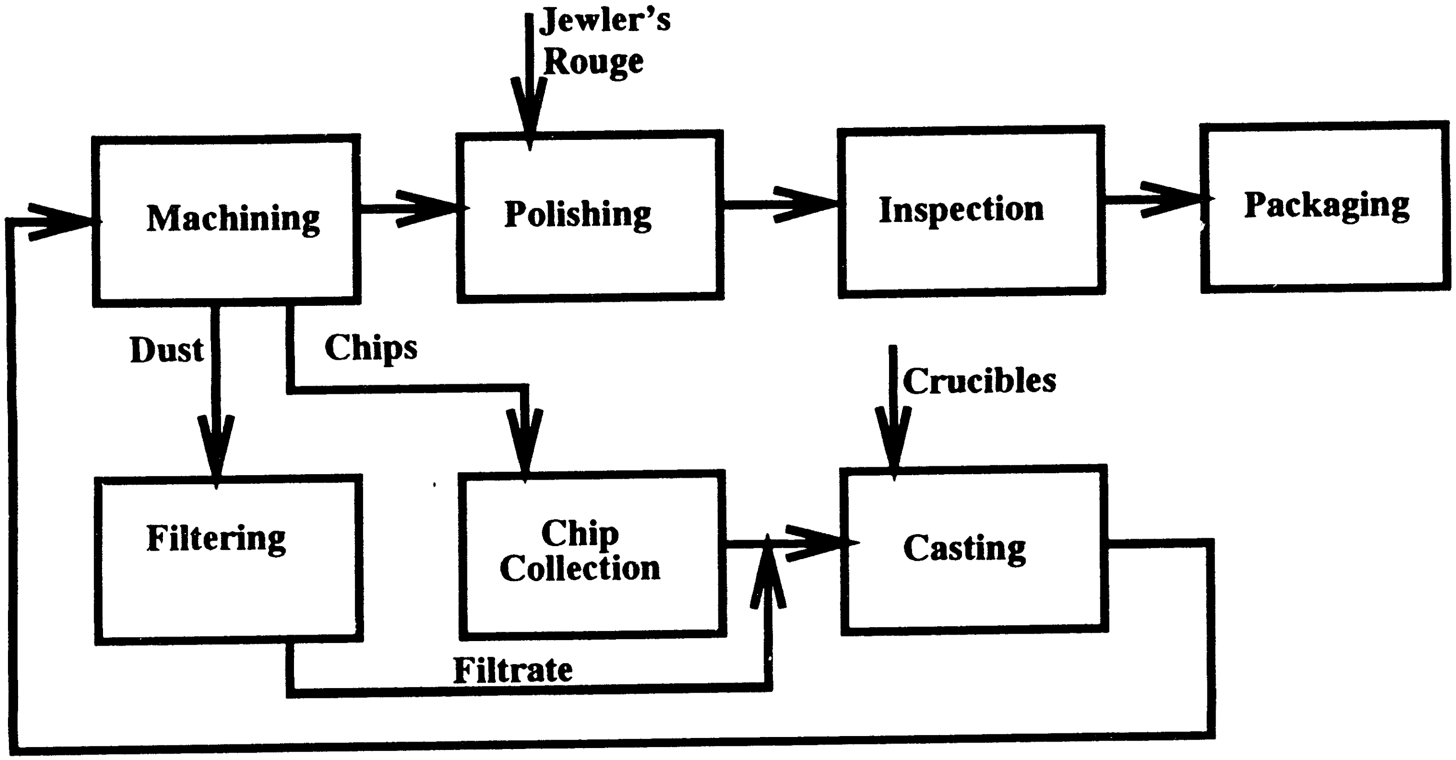

Figure 1.

model was developed in KEE[2] and was running by September 30, 1990. Version 1 of the model was completed during the first week of January, 1991, and verification and validation of the code was completed by mid March, 1991. Approximately three man-years of effort have been invested in the project as of July, 1991. The current customer base includes two full-time analysts at Lawrence Livermore National Laboratories, two full-time analysts at the Y-12 Plant operated by Martin Marietta Energy Systems, Inc. in Oak Ridge, Tennessee, and three full-time analysts at Los Alamos National Laboratory. Current plans for the model call for use through FY1992, and perhaps FY1993 and beyond.

PROJECT 2: THE WESTINGHOUSE IDAHO NUCLEAR COMPANY CPPSIM[3] MODEL

Background

The Idaho Chemical Processing Plant (ICPP) is located approximately 45 miles west of Idaho Falls, Idaho. It's mission during the past 40 years has been to dissolve spent nuclear reactor fuel and recover the unused U-235 (Figure 2). The current contractor, Westinghouse Idaho Nuclear Company, contracted with LANL three years ago to build an object-oriented simulation of the ICPP to replace an older FORTRAN-based simulation that had become difficult to maintain.

Project History

The project started in March, 1989, and was originally scheduled to complete in September, 1990 (Figure 3). Delays to the effort have resulted in the coding portion of the project having been completed in June, 1991, and there has been no progress to date in verification and validation of the model. As of June, 1991, approximately ten man-years had been invested in this effort.

COMPARISON OF THE TWO PROJECTS

Why Did Project 1 Succeed?

The TASP modeling project was successful because several important criteria were met during the course of the project. Had any of these criteria not been met, the project would probably have been terminated. The following paragraphs discuss these criteria:

(1) A working "proof of principal" prototype was required by the end of the first month of the project. The prototype was needed to demonstrate to the customer (DOE) that the analysis requirements could be met with the selected model design. The need to produce rapid prototypes was one of the reasons that KEE was selected as the model software development environment. KEE is well-suited to rapid prototyping.

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[2] KEE: Knowledge Engineering Environment, a product of IntelliCorp of MountainView, California

[3] Chemical Processing Plant Simulation

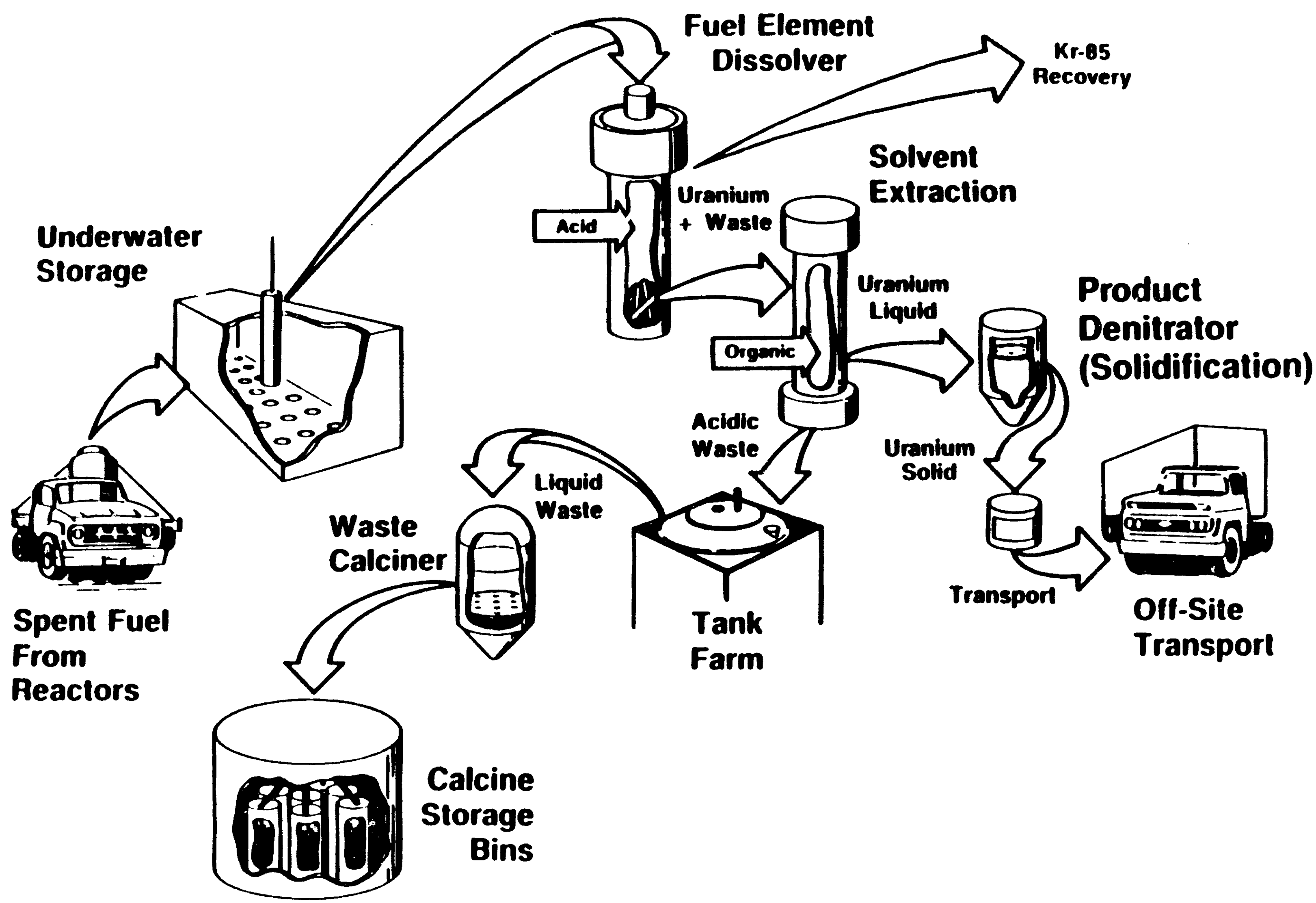

Figure 2. ICPP PROCESS FLOW

CPPSIM Project Schedule

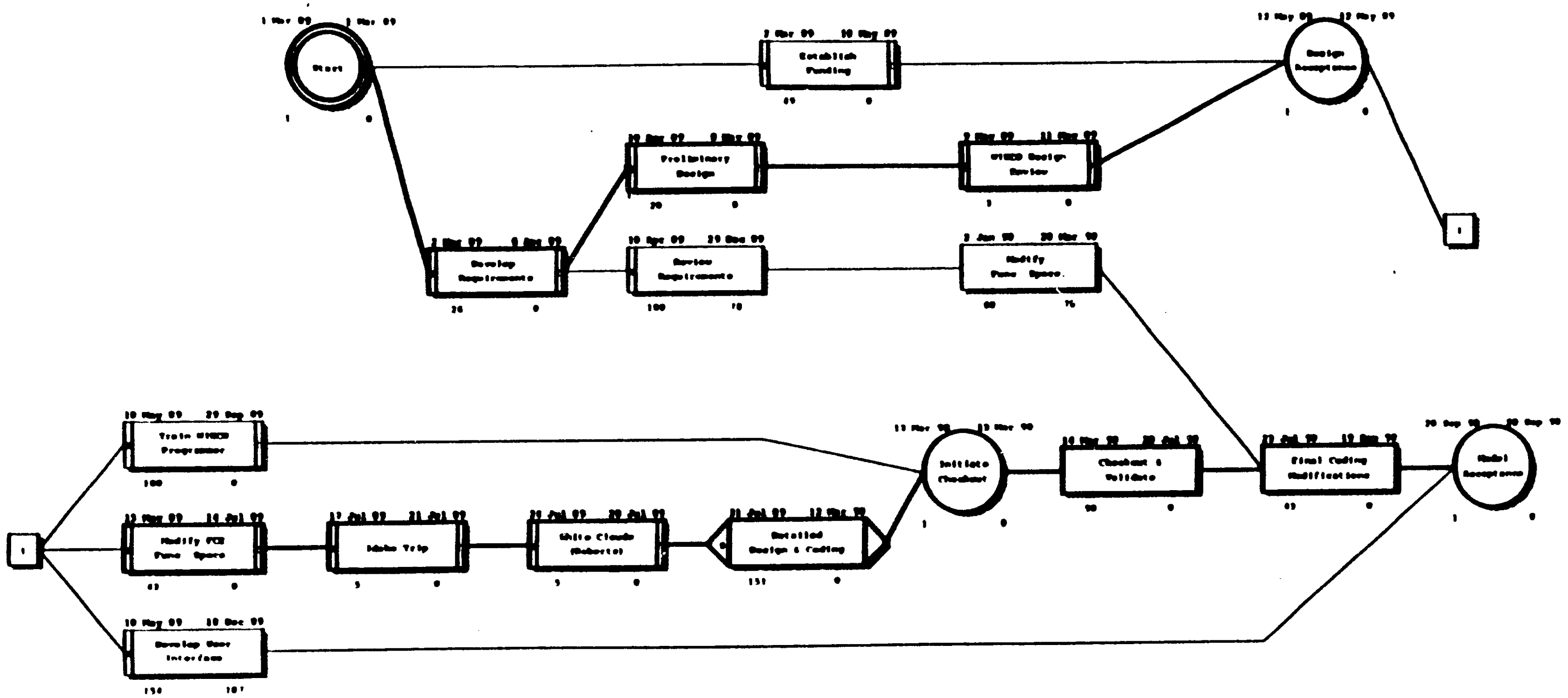

Figure 3.

(2) An effective project team was selected. An experienced analyst was chosen to interface with DOE, and with the project software engineer. The analyst was familiar with the key analysis issues, and was able to present these issues at the appropriate level of abstraction to allow the simulation to address them directly. An experienced software engineer was also selected, since there was no time for "on the job training" on this project.

(3) Deadlines were met. Hardware problems, software problems, and data collection problems were addressed at a sufficiently high level of priority that they were not allowed to impact delivery dates.

(4) There was a remarkable degree of cooperation between sites involved with this project. LANL supplied Lawrence Livermore National Laboratories (LLNL) with copies of the model for their own analysis requirements; in return, LLNL provided LANL with valuable assistance during the verification and validation of the model. The fact that two DOE laboratories were using the same computer model to present their own, and often completely different analysis cases helped give credibility to the model.

(5) The term *AI* was never used to describe the software environment. *AI* is a buzz word that has unpleasant associations to many potential customers, such as DOE. Instead, the software environment was described as *object-oriented.*

(6) Previous LANL modeling efforts had provided a foundation of tools that facilitated the rapid prototyping efforts on this project.

Why Has Project 2 Not Succeeded?

This project started under the best of all possible conditions. The problem was well defined, an experienced project team was selected, and the project had high visibility, which implied a fairly high priority. Given this, why is the model not in production a year after it's original scheduled completion date?

(1) Resource allocation became a problem during the first year of the CPPSIM project, and the problem was never remedied. WINCO selected a very experienced analyst to generate the requirements documentation for the model. As a result, an excellent first draft of the document was produced. Unfortunately, other, higher priority work placed increasing demands on the individual's time. Eventually, he was unable to allocate but a small fraction of his time to the project. Without requirements documentation, the software engineers were at a loss to produce working code. Whenever possible, assumptions were made where requirements documentation was incomplete or missing, and coding continued. In his remaining available time, the project analyst would review the assumptions that the software engineers had made, correct the assumptions, and the engineers would re-work the code. This was very inefficient, however, and the project quickly fell behind schedule.

(2) The changes that are sweeping the rest of the DOE weapons production complex were (and still are) impacting the Idaho Chemical Processing Plant. At the time that the CPPSIM project was started, the modeling requirements were well defined. That was no longer true by the end of the project. The entire mission of the chemical processing plant

was now being reassessed: rather than processing spent nuclear fuel to recover unused U-235, there are proposals that the ICPP simply immobilize and dispose of spent fuel. This would be a drastic change in the nature of business at the ICPP (and to the CPPSIM model).

CONCLUSIONS

There appear to be several very important factors that will determine the success or failure for medium-to-large scale software engineering projects. Often, just one of these factors can cause a project to fail. These factors include the following:

(1) The problem that the software system is to address *must* be well defined, if not by the customer, then by the analyst. An ill-defined problem will guarantee that the software system will not succeed.

(2) Software development efforts of this scale are expensive. The necessary resources must be made available if the project is to be completed on time.

(3) The project time scale must be such that the problem will still exist after the project is completed (or, the requirements must define the "moving target" nature of the problem).

(4) The customer must want the product. This isn't as incongruous as it sounds: changes in management between the start and the end of a multi-year project may cause a shifting of priorities that will prevent a project from being effectively completed.

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