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SYSTEM AND METHOD FOR MONITORING RISK
IN A SYSTEM DEVELOPMENT PROGRAM

STATEMENT OF THE GOVERNMENT INTEREST

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BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates generally to identifying/monitoring risks arising during a development project and, more specifically, to an automated system for determining risk in large development projects such as an expert system for monitoring and tracking ongoing project risk in a large software development project.

(2) Description of the Prior Art

Due to the level of complexity of multi-million dollar programs such as the design, development, and production of a next generation submarine or weapon, it is a formidable achievement to deliver the product on time, within budget, and with a high degree of quality assurance. In a typical complex military system development program, the cost of software
development is a significant cost and often the predominant system cost.

It would be desirable to have an automated means for monitoring the risk levels associated with achieving the desirable outcome of the project as per the standards determined for the project. Various projections, baselines, or plans are made prior to project development in order to estimate the time, cost, and quality standards. Currently, the monitoring and identification of risk in achieving the program standards involves collecting data, visually examining the available data, comparing this with the program baseline or plan, and making a subjective estimation of program risk. For example, if program staffing falls substantially below the expected or planned staffing level during a critical phase of the program, as might be determined by other parameters, the project manager might conclude that the risk in product quality or in meeting with the scheduled delivery date is "high". Staffing then becomes a critical program issue and steps can be taken to add personnel as necessary to reduce the perceived risk. However, it would be desirable to have more quantitative information of risk that is less subjective for a particular project. Preferably, it would be desirable to maintain the same staff of experts used in other projects whose experience could be applied to examine and interpret the information, compare it with the planned project/program objectives, and provide a quantitative measure of the risk level involved to aid the project manager in making
necessary management adjustments to complete the project. While
automated knowledge based systems are well known generally, the
solution to the problems involved in ongoing assessment and
evaluation of project risks as a management tool are not
available in the prior art.

U.S. Patent No. 4,783,752, issued November 8, 1988, to
Kaplan et al., discloses a knowledge based processor that is
callable by an application program to access a knowledge base and
to govern the execution or interpretation of the knowledge base
to find the values of selected objects or expressions defined in
the knowledge base.

U.S. Patent No. 4,860,213, issued August 22, 1989, to P.
Bonissone, discloses an automated rule-based reasoning with
uncertainty system having a three layer structure composed of
representation, inference, and control layers.

U.S. Patent No. 4,942,527, issued July 17, 1990, to B.G.
Schumacher, discloses a computerized management system with two
way communication between the computer and an operator for
receiving information from the operator during a management
emergence stage necessary for developing a plan in machine
readable language for an objective, processing the plan through a
management convergence stage for generating subdivisional plans
for output to the operator and receiving performance information
as feedback for reducing the objective to reality, processing the
management information and feedback information for generating
specifications and quantitative goals for a new version of the
objective, and processing the accumulated management data for producing new organizational policy.

U.S. Patent No. 5,172,313, issued December 15, 1992 as a continuation-in-part to the above cited U.S. Patent No. 4,942,527, to B.G. Schumacher, discloses additional processes related to the above-cited computerized management system such as processing through the emergence and convergence stages to analyze and selectively remove tasks which have exceed planned task time, perform system analysis for directing performance for the next task and calculating the scheduled time for the remaining tasks in the series.

U.S. Patent No. 5,189,606, issued February 23, 1993, to Burns et al. discloses an integrated construction cost generator that may be used to project costs for construction projects rather than a method for monitoring ongoing project risk.

U.S. Patent No. 5,208,898, issued May 4, 1993, to Funabashi et al. discloses a knowledge processing system in which a grade representing a degree at which an event is satisfied or unsatisfied is obtained depending on a condition part represented in a form of a logical arithmetic expression including an expression of a fuzzy logic and on a grade of satisfaction of the condition part generates rules on assumption of unmeasurable events associated with states of the external field of the system so as to add the rules to the rules related to the unmeasurable events.
U.S. Patent No. 5,293,585, issued March 8, 1994, to N. Morita, discloses an industrial expert system for use in designing a plant system or devices thereof and in fault detection, that includes a knowledge base having a rules section for describing deductive inference rules. The system uses a simple construction to efficiently perform detection of fault logic by using specific formula or calculation of parameters representing features of a fault which are to be performed during inference.

U.S. Patent No. 5,586,021, issued December 17, 1996, to Fargher et al., discloses a method for planning a production schedule with a factory. A capacity model is determined by determining a plurality of contiguous time intervals, partitioning the factory into a plurality of resource groups, and determining a processing capacity for each of the resource groups for each of the time intervals. For each job to be planned, the job is divided into a plurality of processing segments each of which is represented with a corresponding fuzzy set. A completion date and confidence level can be predicted for each of the jobs so the jobs can be released to the factory and devices fabricated according to the requirements of the jobs.

U.S. Patent No. 5,737,727, issued April 7, 1998, to Lehmann et al., discloses a process management system for operating a computer that includes a graphical interface for graphically presenting a process or portion thereof to a user.
In summary, while the prior art shows numerous general purpose knowledge based system and various specific purpose systems, there is not shown a system for monitoring and identifying risks associated with large projects such as software development projects. Consequently, there remains a need for a system to quantify various types of ongoing risk that may arise during project development using an objective predetermined basis. It would also be desirable to have means to objectively quantify overall project risk on an ongoing basis. Those skilled in the art will appreciate the present invention that addresses the above and other problems.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an automated system and method for identifying and monitoring risk associated with a development project. It is another object of the present invention to use a rule based risk assignment system for determining the risk. It is yet another object of the present invention to provide an output in chart form that plots a plurality of risk factors over the duration of the project.

It is yet another object of the present invention to provide an overall risk from said rule based risk assignment system. These and other objects, features, and advantages of the present invention will become apparent from the drawings, the descriptions given herein, and the appended claims.
In accordance with the present invention, a method for monitoring risk is provided that is related to a successful completion of a development project comprising steps therefore. A plurality of variables are determined relating to the successful completion of the development project. A respective baseline is projected for each of the plurality of variables for the successful completion of the development project. Data values are collected that relate to each of the plurality of variables with respect to time. A database stores therein rules based on knowledge developed from one or more experts relating to the plurality of variables for interpreting the data values with respect to the respective baseline. The database also stores the data values and the respective baseline for the plurality of variables for determining a plurality of risk levels related to a probability of one or more undesirable events. A visual output is provided that is representative of each of the plurality of risk levels. The method is particularly applicable to development projects that involve development of a quantity of software. In a preferred embodiment, the plurality of risk levels is quantifiably determined and plotted. The visual output representative of the plurality of risk levels may comprise a graph showing each of the plurality of risk levels plotted with respect to time throughout the development project. The risk levels may be determined and plotted at selectable time intervals. Preferably, the data values are converted to metric values. The metric values are used to determine the plurality of
risk levels. Each of the plurality of risk levels may be expressed quantitatively such as with a numerical description related to risk or in a non-numerical way such as high, medium, and low risk. In one embodiment of the invention, the data values are collected related to staffing levels, project requirements, and to the number of source lines of code that are required.

Thus, the invention comprises an expert system for determining risk in the development project. The expert system may selectively use a first or second plurality of rules for identifying and monitoring the plurality of risk factors. The system has a plurality of inputs related to each of the plurality of risk factors for monitoring during the development project. Each of the plurality of inputs is preferably associated with a quantifiable and weighted value and the database stores the history of each of the plurality of inputs. A computerized program is used for evaluating the plurality of inputs with respect to the quantifiable and weighted value and for comparison with the plurality of projected base levels. From this, the program determines the plurality of outputs related to the plurality of risk factors. The computerized program is operable for producing the historical chart that may show historical values for each of the plurality of risk factors with respect to a time line for the development project. The computerized program may be manipulatable so that each of the plurality of
inputs and outputs may be selectively removeable and so that
additional inputs and outputs may be added.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention and many of
the attendant advantages thereto will be readily appreciated as
the same becomes better understood by reference to the following
detailed description when considered in conjunction with the
accompanying drawings wherein corresponding reference characters
indicate corresponding parts throughout the several views of the
drawings and wherein:

FIG. 1 is a block diagram of a rule-based knowledge system
in accord with the present invention;
FIG. 2 is a chart in accord with the present invention of
input data such as source lines of code base line estimates
versus actual source lines of code required; and
FIG. 3 is a chart in accord with the present invention of
output data showing a plurality of risk levels as well as a total
risk level with respect to time.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and, more particularly, to
FIG. 1 there is shown a high-level block diagram for a knowledge
or expert system 10 in accord with the present invention. Expert
system 10 includes rule-based risk assignment section 12 that is
preferably formulated as a series of rules such as if-then type
statements or other logical statements. System 10 may be
referred to as an AI (Artificial Intelligence) or expert system.
In practice a set of input measurement characteristics 14, 16,
18, and/or others will translate into a set of outputs 20, 22, 24
and/or others from logical statements, algorithms, and the like,
provided by experts who are knowledgeable in analyzing this type
of data and determining an output risk level. The expert's
rationale is, in effect, captured and stored within the rule-
based system. The knowledge, lessons learned, and past
experience are used to form the basis of the system. The rules
capture the steps that an expert takes in examining and
interpreting the measurements, comparing them to the expected
measurement behavior that is predicted for a minimal risk that
may be referred to as the baseline, plan, or statistical norm,
and then determines a measure of the project risk that will be
performed by rule-based system 10. The rules of risk assignment
module 12 are designed to take into account all possible
characteristics of input measurement data such as 14, 16, and 18,
and to provide the corresponding outputs 20, 22, and 24 at some
points in time during the development project. In one embodiment
of the invention, the inputs may vary or be automatically varied
in accord with progress of the project. Some inputs may be added
or eliminated. The same is true of outputs that may be changed
either automatically or by the project manager. In addition,
rules module 12 may contain a plurality of rule sets which can be
selectively chosen by the project manager depending on the
project being monitored.

Inputs 14, 16, 18 and/or others may be weighted by weighting
levels 26, 28, 30 and/or others and may be stored within database
32. Thus, the inputs can be weighted to define the relative
importance of the data measurements. If desired, weighting may
change during the course of the project by design or by the
project manager. Preferably rule-based output 20, 22, 24 and/or
others is characterized quantitatively as numbers such as between
0 and 1 where 1 is maximum risk and 0 is minimum risk. Other
characterizations could also preferably be selectively made so
that, for instance, the risk levels could be designated low,
medium, and high.

The overall program preferably controls input application
and will preferably send forms, either paper or computer forms
(sent electronically) and the like to those who are responsible
for providing the inputs at the appropriate times. A server may
be set up for this purpose so that the system may operate on a
local network or through the Internet if work is accomplished at
numerous locations. The system may be implemented on a PC for
use by the project manager, shown as computer 11 in FIG. 1.

To provide understanding of the system, a simplified example
is given to illustrate operation of the system although it will
be understood that in practice the operation is much more
complex. We will assume that weighting is equal so that all data
is equally relevant. The system is especially suitable for
monitoring and identifying risk in the development of a substantial quantity of software as may be used in a typical military system development program. In this example, inputs 14, 16, and 18 are collected and entered on a quarterly basis. A cumulative review of input 14 may be represented as shown in FIG. 2 that refers to the source lines of code (SLOC) needed for the project. Bars 34 show the base line or projected values for source lines of code required. Squares 36 show a line graph of the actual number of source lines of code as the project is developed. As can be seen there is a substantial change in the source lines of code required for project completion over that planned. Database 32 stores these values. Metric computations are made with the rule based risk assignment, as discussed in more detail subsequently, such that input 14 of SLOC data is computed to a metric or form for use with rule based risk assignment module 12. Risk assignment module 12 then processes the actual and corresponding planned data inputs to compute risk levels according to predetermined criteria. The risk levels are stored in database 32. Historical data chart capability module 38 is used to produce a chart showing a plurality of risk levels over time and preferably including an overall or total risk level. A sample output is shown in FIG. 3 where bar 40 is representative of risk levels associated with SLOC data. Other inputs for the simplified example include staffing levels or number of personnel required as input 16 and planned system requirements as compared to actual requirements of the system as
input 18. FIG. 2 (showing SLOC data) is representative of the
general format for this type of data.

FIG. 3 is preferably produced in a form by historical
charting module 38 to show all information necessary to the
project manager to evaluate risk levels and to make decisions to
mitigate risk. Thus, bars 42 in FIG. 3 show the system
requirements risk levels associated with input 18 as they change
over the course of the software development project.

Bars 44 show staffing level risks associated with input 16
as they vary during the course of the project. Risk assignment
module 12 also preferably produces a total or overall project
risk level that is indicated as bars 46 in FIG. 3. As can be
seen, overall project risk has reached a maximum probability of
failure by September of '99 so that action may be warranted to
reduce risk levels. Risk levels were calculated to be in a range
between 0 and 1 where 0 represents no apparent risk and 1
represents maximum risk, as discussed subsequently.

Thus, data inputs 14, 16, 18 and/or others may include the
number of system requirements based on the system specification
and the actual number of requirements that may often change
during the development process; the number of planned personnel
for each phase of development (design, coding, and testing) and
the actual staffing employed during the product development; and
the number of planned or estimated source lines of code (SLOC)
upon which the contract was based and the actual amount required.
It will be understood that system requirements often change during the development as compared with the original system specification, and therefore generate increased development costs. Therefore it is necessary for risk assignment module 12 to compare the actual requirements with the original specification baseline requirements. The metric computed for each input may be for the present case defined as the percentage of requirements (including new ones) that are above the original values. Since staffing is another important parameter which can impact the system delivery schedule, the metric may be computed as defined as the percentage of workers below the base plan staffing level. If this metric is considerably off on the low side, then there may be a schedule impact so that staffing risk is assigned based on this metric. A third metric is computed that may relate the percentage of actual SLOC to the initial SLOC estimate which was the parameter used to bid the project. If during development, the actual code that is developed greatly exceeds the original proposed amount, then the cost may increase prohibitively. SLOC risk is assigned based on this metric. Risk levels are determined by module 12 based on predetermined rules that map software metric values to a quantitative level of risk.

In the present example, if-then type rules might consist of the following rules:

1. If the requirements metric is 0% to 10%, then the risk of additional costs is 0.1. If the requirements metric is 10% to 20%, then the risk of additional costs is
0.2. The progression continues to 90% and higher which correspond to an upper risk limit of 1.

2. If the staffing metric is 0% to 10%, then the schedule risk is 0.1. If the staffing metric is 10% to 20%, then the schedule risk is 0.2. This progression continues to 90% and higher which correspond to an upper risk level of 1.

3. If the SLOC metric is less than 100%, then the risk level is 0. If it’s 100% to 110%, then the product quality risk is 0.1. Only when the percentage is greater than 100% does a risk level get assigned. If the metric is 110% to 120%, then the product quality risk is 0.2. This progression continues to 190% and higher which correspond to an upper risk limit of 1.

As seen in FIG. 2, actual SLOC values exceed the planned values in December 98 and continuing through September 99. This should alert the program manager that there are increasing risks in this area as indicated in FIG. 3. Likewise other risk levels are rising and the overall or total risk level rises dramatically. At this point, the program manager will be alerted to the problem and can take measures to diminish the risk. All information including rule information is preferably available for reference as needed.

In this example, each calendar quarter rule-based module 12 generates a component risk level and a composite risk level by
combining the three components, i.e., requirements, staffing, and SLOC risk levels. Other time intervals may be selected. Weighting or variable weighting may be applied here if one parameter is more important than others.

It will be understood that a relatively simple example is given to quickly convey the concepts of the system operation. However, in actuality, such systems designed for large development programs may be extremely sophisticated with substantially more input parameters, substantially more rules and component risk level outputs.

In summary, the present invention is operable for using multiple inputs related to risk factors as described in FIG. 1 and FIG. 2. The data is stored and operated on with a rule-based expert system to produce a plurality of outputs preferably in chart form as indicated in FIG. 3. Database 32 stores historical values for risk levels, data, baseline projections, and the like as needed to produce the plurality of outputs. Risk projection module 12 provides risk levels based on predetermined standards that are preferably in quantified form. Historical data chart module 38 produces data such as the chart of FIG. 3 in a format that allows the project manager to quickly identify and assess project risks.

It will be understood that many additional changes in the details, materials, steps and arrangement of parts, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art.
within the principle and scope of the invention.
SYSTEM AND METHOD FOR MONITORING RISK
IN A SYSTEM DEVELOPMENT PROGRAM

ABSTRACT OF THE DISCLOSURE

A computerized system and method are provided that may be used to project a plurality of risk levels that may develop during the course of a large development project. A plurality of inputs are stored and converted for use to a metric that is used by an expert knowledge rule based system to determine a plurality of risk levels that develops relating to successful completion of a large development program with respect to elements such as cost, time of delivery, and quality. A plurality of outputs are provided in a form that can be used by a program manager to reduce the level of risk that may arise. In a preferred embodiment, the plurality of outputs are provided in a quantified manner that may relate to a probability of failure of one or more aspects of the development program. The rules are based on the knowledge and experience of experts and are predetermined so that risk levels are objectively quantified prior to beginning the project rather than subjectively determined during the course of the project. The system can be implemented on a PC and can be used by a metric analyst or program manager.