

# PLANNING AN IT PROJECT IMPLEMENTATION: COMPARING DIFFERENT PM TECHNIQUES

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## ABSTRACT

A project team's objective is to plan the implementation of Electronic Medical Record (EMR) system in a hospital. In this paper we are focused on time management. This is a decision making process for an IT implementation with typical and challenging tasks for many IT projects: time limits, latencies, need for rework, and eventual changes of the requirements during the project implementation time. We apply several Project Management (PM) techniques (from CPM and PERT to simulation and GERT). From the educational point of view, this case connects many IS areas which are usually taught in Business Schools as isolated topics.

## A BRIEF DESCRIPTION OF THE CASE AND THE CLASSICAL PM APPROACHES

The State Department of Health has mandated the implementation of Electronic Medical Record (EMR) system in all hospitals that exceed a certain bed capacity. This case is based on the real EMR implementation in one of the Upstate New York hospitals. All numbers used for activity durations, costs and some of the tasks used in this study are fictitious. The policy is motivated by evidence showing that EMRs reduce medical and nursing errors. A deadline for implementation has been imposed and failure to meet the deadline will cost substantial fine. Since the hospital already abandoned one EMR project, the deadline is fast approaching; it corresponds to 25 weeks from the project start date (deadline requirement). The project management team has been charged with many tasks, from which we selected nine to be discussed in this paper: Display the project graphically; Estimate the time to completion, if no unexpected delays occur; Identify Critical Activities (CA, sometimes called the "bottleneck" activities) where any delays will automatically postpone finishing the project; Determine times for the earliest start (ES) for all activities (to be used in the initial scheduling); Determine times for the latest start (LS) for all activities that will permit completion by the estimated completion date (to be used in "last chance" scheduling); For non-critical activities, determine the amount of delay (slack) that can be tolerated without delaying project completion and discuss options to re-allocate resources if there are slacks in the base project; Given uncertainties in estimating durations, determine the probability of project completion by the deadline (and thereby avoiding the fine); How to manage possible needs for re-work because of latency or sub-standard quality of execution of certain activities; Discuss the limitations of the analysis.

We begin by cataloging all required activities, their precedence relationships, and their estimated durations (Figure 1). For now, we will grant deterministic status to these durations (in fact, these values are expected values used in PERT approach and it will be discussed later in this paper). We choose an Activity on Node format (Figure 2). The activities are then depicted in a network diagram (Figure 3). Observe that initially we assume simple precedence relationships in the network diagram. That is, we cannot start an activity until all immediate predecessor activities have finished.

Activity	Description	Immediate Predecessor	Estimated Duration (weeks)
A	Hardware and Network Upgrades	none	4
B	Design of Custom Applications	none	5
C	Installation of Core EMR	A	4
D	Installation of Custom Applications	B,C	2
E	Training - Hospital Staff	D	4
F	Training - Physicians	D	5
G	Integration Test	E,F	2
H	Shadow Use	G	6
I	Embed PACS (Picture Archiving and Communication Systems)	G	3

Figure 1: Project Activity List

Name	Duration
ES	LS

Figure 2: A graphical symbol used to present an activity node with four data: Name, Duration, Early Start (ES) and Late Start (LS).

a rectangular range of four cells for each node. To be more visible, we paint the cells of each node in selected color (designer may use different colors according to groups of activities, to get a color coordination). The upper two cells Activity Name and Duration (Figure 2) are filled by transferring the existing data from the entered table using simple linking with the appropriate cells in the table (why not to copy?) Please note that task durations might be result from calculations made in this or some other worksheet (like we will apply in PERT solution). The bottom half of the range (cells named ES and LS in the Figure 2) will be prepared later. Activities (nodes) are connected with **arrows** (or arcs) using the drawing tools provided in Excel (from the Shapes icon). These arrows are drawings and they are not carrying any functionality in this example.

We use the CPM algorithm how to calculate ES and LS and to find PM information. Early Start (ES) signifies the point in time at which a given activity may start (assuming that all immediate preceding activities have been completed). Using this estimate will expedite manual solution since the user does not need to recalculate from the Start node every time. The ES should be entered into the lower right-hand square using the formula (see Figure 3) which is based on data from the immediately preceding node: its duration + its ES (there must be an arrow linking the two activities). If there are two or more immediate predecessors, ES will be the **maximum** ES of all directly preceding activities (see formula for D, in the cell J16 in Figure 3). The value for ES in the finish node represents Critical Time (CT). It is 23 in this case. The major inconvenience of this technique is that the project manager must create an original network for every project (actually, there is a small chance for reusing some of existing sub-networks, but designer must be very careful in that attempt).

The lower right-hand place of every node range (Figures 2 and 3) is reserved for the **Latest Start (LS)**. Latest Start indicates the latest possible time at which an activity may start without extending CT. We assume that the project manager will try to finish any given project as quickly as possible. This will make the **LS** for the **Finish** node equal to **ES**. The LS for any activity is calculated by subtracting the current activity duration from the LS of its immediate successor. Problems arise when there are two or

The next step is to use one of the traditional PM methodologies and get a plan and the initial results (“baseline”). Since the number of tasks is small and the relationships between them are very simple, there are many techniques to solve this deterministic problem (from easy algebraic procedures, Gantt chart, CPM to use of PM software). Our approach is to use CPM supported by an Excel support for decision making. In the same time, this will be the base model for developing the PERT and GERT models, later in this text. We will use an Excel spreadsheet to draw a network and use some Excel functions to ease the calculations. First, in the Northwest area of a spreadsheet we enter the project activity list (Figure 1). A simple notation will represent activities in nodes (see Figure 2). Continue by creating

more immediate successors; in this case, we calculate the **minimum** LS, for all outgoing arrows. Slack is the time available between ending one task and beginning the next (immediate follower) and must be non-negative ( $S \geq 0$ ). Slack or  $S(\text{task})$  is defined as the difference between LS and ES:  $S(\text{task}) = \text{LS} - \text{ES}$ . If the slack value for an activity (node) is = 0, this activity is defined as critical (obviously, any delay in any critical activity will create the project's delay). Figure 3 presents the complete solution after calculating ES, LS and Slacks for all nodes and showing Critical Activities (CA). Based on CAs, designer needs to present Critical Path (or paths). Here, the CP is A-C-D-F-G-H with  $\text{CT} = 23$  weeks.

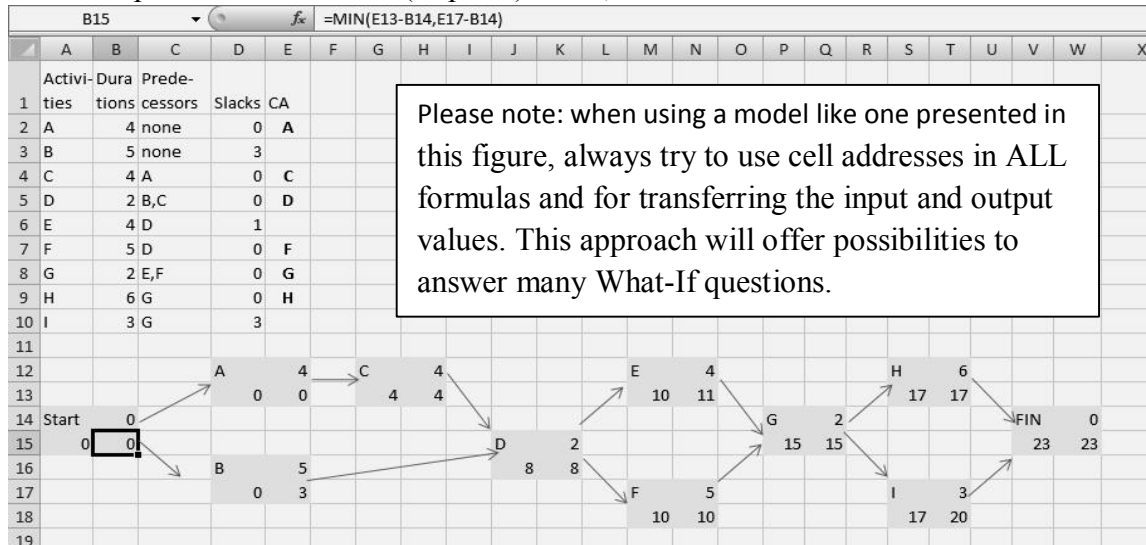


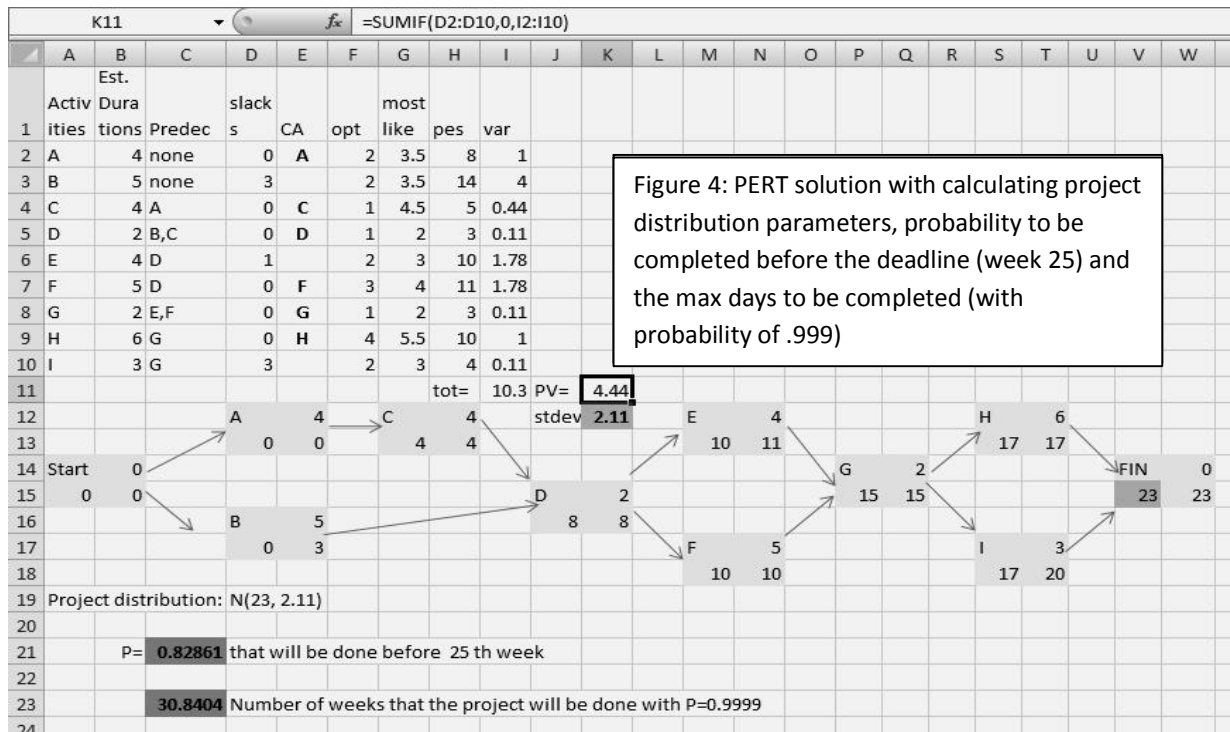
Figure 3: After drawing a network, the next step is to calculate ES and CT. Formula in E12 is =B2. Formula for the ES in the node C is =D13+E12. Formula for ES in the node D (in the cell J16) is =MAX (D17+E16, G13+H12). Formula bar shows the last formula to be entered in the network for calculating the LS in the node A. To find if the activity A is the CA, we used the formula: =IF(D2=0, B2, "") and this formula can be copied ("filled") down for all activities

So far, we created a project network and baseline plan, and answered to the first 5 questions. With the sixth question (from the list of nine suggested in the Introduction) designer in fact starts the management process for this project. Since there are activities with slack, one idea is to take advantage of the slacks in activities B, E and I using a possible reallocation of resources FROM these activities (making them "longer") TO critical activities (to make them "shorter"). For example, designer may extend activity B for up to three weeks, E for up to one week and I for up to three weeks. This will make all activities to be critical (and make the project manager very worried), but will release resources from those activities. Obviously, during the PM process, designer should not use all slacks if the goal will be to shorten the CT! In real situation, the question is: how and what resources to re-allocate from non-critical activities to make some of critical activities shorter? Practically, what to use for possible reallocations: people, equipment or money? For example, if we will expand activity B for 2 weeks, making activity A to be shorter for one week, and, similarly, if expanding the activity I by 2 weeks could shorten H by 1 week, then the new  $\text{CT} = 21$  and the new plan will leave only E to be the non-critical activity! All other ideas to shorten the CT, like "crashing" are not included in this case study.

The previous discussion generated sufficient information (based on fixed activity durations) to reach the question 7: to use uncertainties in estimating durations to determine the probability of project completion by the given deadline.

As mentioned earlier, all deterministic values used in the CPM method were in fact expected values based on triple estimates prepared for the PERT calculations. All PERT approaches use the weighted average of optimistic (o), typical (t) and pessimistic (p) durations for each activity or task. To calculate

expected or estimated duration (d) for each activity we can use the known formula:  
 $d = (o+4*t+p)/6$  . Designer could choose different weights instead of the most common: 1, 4, 1. Also, have in mind that the variance for each activity is:  $V(\text{activity})=((p-o)/6)^2$  . PERT input and output data and solutions are in the Figure 4. Using the project variance (defined as the sum of variances of all



critical activities, PV=4.44) we accept that the project follows Normal distribution: N(23, 2.11), with the mean of CT=23 and the standard deviation of 2.11. In cells C21 and C23 (both darker in Figure 4), we are using Excel built-in functions for the Normal and Inverse normal cumulative distribution, showing that there is 83% chance that the project will be done before week 25, while the project will be done before 31 week with a probability of 99.99%. This way we answered the seventh question.

Please note that majority of software packages do not cover calculation of the Project Variance or usage of these probabilities in decision making.

We can prepare several additional PM scenarios. For example, using the most optimistic scenario will give CT=12! Some members of the management team may claim that the best approach will be to try this idea and to allow re-work for certain nodes (with assumed probabilities based on the historical data). If necessary, it means to organize a new model with loops for re-doing selected activities. Traditional PM approaches do not support these options and they are often seen as typical shortcomings of currently applied PM techniques. Because of that we introduce **Graphical Evaluation & Review Technique (GERT)**. The new model (based on the existing model presented in Figure 3) will discuss selected ideas from the GERT approach.

## INTRODUCTION TO GERT TECHNIQUE

As stated above, traditional PM models do not offer solution for relatively common problems in managing the IT and production projects. Among others, the problems are: need to rework and branching (based on decision made during the previous activity) or a possibility to take several paths for reaching the succeeding activity with given probability. Also, classic models (based on CPM) do not allow “revisiting” the previous nodes in the case when tasks need to be re-examined or reworked.

The simplest solution for (at least some of those issues) seems to be to allow some additional time for selected tasks or to add extra time to the Finish node (to put the duration  $>0$  for the Finish node). In the model, it will make all activities to have a slack (known as “buffering”). This will extend the project time (CT). Designer could identify the critical activities and critical path(s) using the given value for duration of the Finish node (all CAs have a slack equal to that value). But, the problem is not solved: now, the project is planned be to ALWAYS longer (even when the re-work will not be necessary).

To summarize this discussion, PM literature list major challenges for the traditional PM methodologies:

1. All immediate predecessor activities must be completed before a given activity can start
2. No activity can be repeated and no “looping back” to predecessors is permitted
3. The duration time for an activity is restricted to Beta distribution (anticipated as the Normal distribution) for PERT and to a single estimate (deterministic) for CPM
4. The critical path is always considered the longest even though the variances include the likelihood of other paths being longer
5. There is only one terminal event and the only way to reach it is by completing all activities in the project.

PM concepts which allow conditional branching, rework and looping use the common name: **GERT**.

When a project is presented in the GERT environment, designer may apply the Monte Carlo simulation to estimate the major characteristics of the model and these outputs will be used for managing the project. After reviewing the challenges presented above, it is fascinating that many IT projects can be easily identified as good candidates for GERT modeling.

To be able to prepare a GERT version of our model, it is necessary to select one or more activities to be considered for re-work or to introduce possible feed-back loop in some points (nodes). Project manager should apply his/her own experience or consult literature when making those selections.

This discussion could lead into two areas:

- a) What about quality? It is possible to assume that the highest quality will be produced if all activities are prepared slow (e.g. using the pessimistic durations)? The IT projects’ experiences will tell us that it is not always true! Also, applying this to this case it means that the project will be late 16 days, forcing hospital to pay huge penalty!
- b) What if we will put all durations to be stochastic? After choosing the appropriate probability distributions for all (or just selected tasks), we need to change our model. One model is in Fig 5 where we can use Crystal Ball or Excel random numbers to create variable durations of activities.

Presented model is based on the knowledge of the solving the PM projects using the CPM, elements of the theory of probability and Monte Carlo simulation. We implemented this model using Microsoft Excel and Visual Basic for Application (VBA). This is the most convenient approach because of availability of the software and the knowledge of typical users who will need to develop and execute appropriate types of models in their PM practice. Simulation software could be quite expensive.

For this case study we are proposing a simple GERT method to estimate network characteristics such as the project time. Presented method starts with a design of a stochastic network. After running a set of Monte Carlo simulation, VBA or Crystal ball program generates outputs. The PM manager will need to validate the model and to analyze outputs and compare initial information with results based on the traditional PM techniques.

Figure 5 presents the model with feedback loop (it is quite similar to a model with the re-working). Let us assume that there are problems with the quality of work in the node D, and also some issues about the quality of training in the node G. It means that project manager needs to organize rework of preceding activities B and C for D and E and F for G. This way, if there is known probability when the problems will occur, a feedback loop model could be realized using available software.

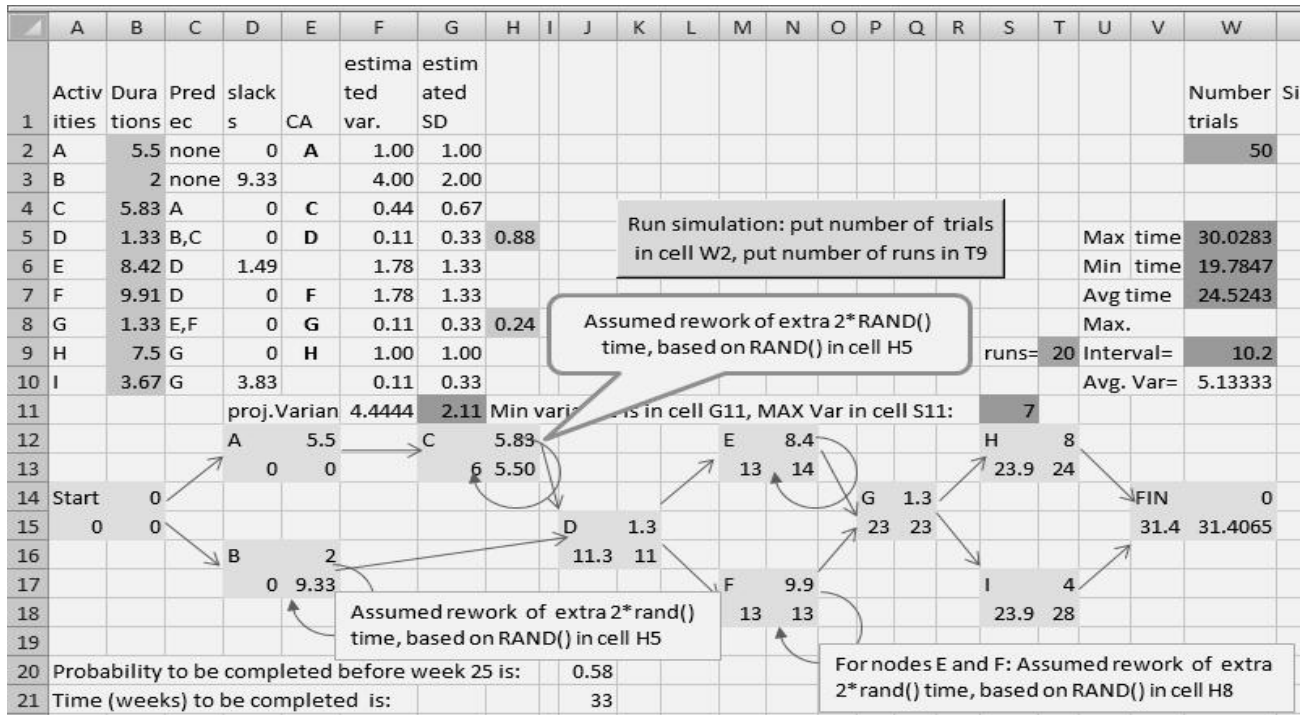
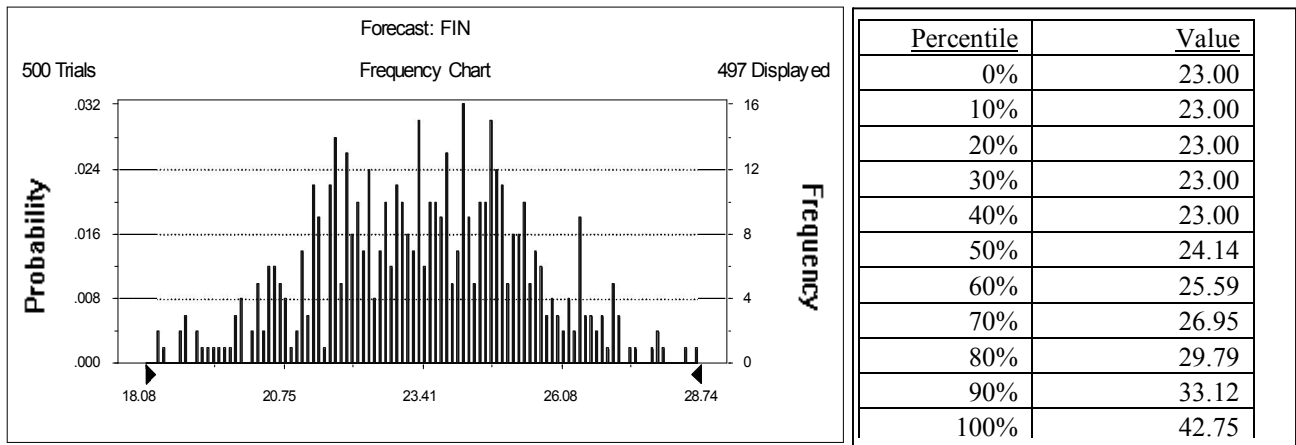


Figure 5: Modeling a feedback option (GERT methodology). Simulation of this model uses Crystal Ball. Results are presented below.



Note that this EMR problem does not offer conditional branching since all presented activities must be executed and we cannot demonstrate this GERT technique subtype using this project.

### VERY BRIEF CONCLUDING REMARKS

The case puts together several PM methodologies, and introduced simple Excel based models (with a small addition of VBA and Crystal Ball) to be used for everyday college examples to create links between disciplines: from using spreadsheets and computer programming, probability and statistics to information systems (designing and using ready-made programs) and decision making and management. Due to page limitations, references are available upon request from yasha@albany.edu.

Acknowledgment: special thanks to our colleague Peter Ross, School of Business, University at Albany.