ADMINISTRATIVE PROCESS MODELING: WBS AND PROJECT MANAGEMENT APPROACHES REVIEW

M.Sc. Trashlieva V. [1], M.Sc. Radeva T. PhD.[1]
Department of Electrical Power Engineering – Technical University of Sofia, Bulgaria
vesselina.trashlieva@gmail.com

Abstract: *Every optimization problem needs its appropriate model. An administrative process is specific but it also requires optimization. In this paper a practical review on the preceding stage of process decomposition is made. A review on possible approaches to the further modeling of an administrative process as an event-oriented process deriving from project management practitioners is done. The problem of decisions making under risk and uncertainty conditions is explained in the case of a discrete-event administrative process model and two approaches for uncertainty presentation are proposed for review.*

Keywords: OPTIMIZATION MODELING, ADMINISTRATIVE PROCESSES OPTIMIZATION

1. Introduction

Most project management software products provide opportunities for a simulation of the development with possible changes in the duration or resources available for a given operation[1]. But the opportunities for process optimization, i.e. the model size reduction is very limited and basically it provides for the analyst to decide for himself alone on what changes to make[2]. This is why project management and the underlying modeling approach of the dynamic programming modeling are considered arts[3].

In the approach proposed in [4] for the reduction of the total time the difference between the number of operations (respectively nodes) in the critical and shortest path gives the initial conditions of the optimization approach and the possible optimal final result, namely how many of the initial number of operations could be appropriately removed. The analyst alone can specify which nodes and operations will be removed with the increase of optimization iterations. Algorithms produce the relevant results after each removal of the elements.

The optimization approach thus implemented is semi-heuristic: heuristics are used because of the fact that in order to actually reduce the number of elements, real knowledge of the specifics of the process is necessary. The optimization structure itself, in turn, is purely technical - from the maximum to the minimum. Of course, in this situation, the final result is, in a sense, optimal: the location and interconnections between the elements is such that further simplification will lead to deterioration or, in other words, the best that can be achieved under the constraints arising from the conditions themselves. So a theoretical and technological engineering managerial approach to a problem is available that is difficult to fit into the classical technical and techno-economic processes considered by the same theory.

On the way of research and analysis, the idea of modifying techniques and algorithms from the graphs theory and project management in the view of the specific task and its specificity is reached. An interpretation of the problem and the classical algorithms are found that combined together deliver the desired results. Typically, for the administration closest to a theoretical model is the block diagram of a process. Modeling is rare in administration and it is often performed by specialists outside the administration who are trying to explain the *cause-and-effect* relationships between operations. Frequently the descriptions of the procedures use rudimental verbal descriptions, lacking the elements of analysis and decomposition into elementary separately manageable components[5,6]. In this line, the proposed approach is also interdisciplinary. In its composition, elements of the following technical and techno-economic directions exist: system analysis, modeling and process management, network minimization, optimization, adaptability, robustness, operations research including both certainty and risk and uncertainty decisions making. At the heart of all this is a systematic and managerial approach to a problem of a social-economic importance.

2. The Work Breakdown Structure (WBS)

Work breakdown structure (WBS) or Decomposition into elementary separately manageable units

WBS is a methodology for defining and grouping discrete elements (tasks, activities) in such a way as to assist in the allocation and determination of the overall scope for an activity / process / project. i.e. this is the structural description of the functional decomposition of a process.

An element of a structure can be a product, data, service, or combination. The WBS is thus the basis for developing the necessary management structure, i.e. to elaborate a model for detailed price evaluation and quality management, together with the possibilities for developing a work plan (schedule) and implementation control. Additionally, WBS is a dynamic tool and can be revised and modified according to the designer's requirements and new changes in the process.

WBS is a tree and hierarchical structure that shows the subdivision of the effort needed to achieve the ultimate goal - program, project, process and contract. When talking about a process / project, WBS begins with: the final goal and its:

- successive decomposition (with respect to subordination and consolidation) into separate *manageable* components that ...
  - are grouped (or better - *clustered*) according their volumes, terms and responsibilities in systems, subsystems, components, tasks, subtasks and work complexes,
    - including all steps in the way to achieve the final goal

WBS is the basis for the overall planning, management and organization of workflows in *determined* increments from which a technical, time, cost and resource plan can be developed. Through this structuring it is possible to sum up the subordinate costs of materials, time, etc. and how these fit into the same parameters in the higher levels. A problem description is constructed for each element. This technique is known as System Decomposition and is used to define and build a complete organization of a given process.

WBS is generally organized around the *planned results* rather than on the basis of the work needed to be done to reach them (i.e. the planned activities). Since the planned results are the desired results at the end of a process, in this case - not "*desirable*" but *mandatory*, they form a relatively constant set of parameters to help describe the prices of all the planned activities required for reaching the required results. A well organized WBS allows the assignment of each specific process activity to just one and only one terminal element that is *an unit.*

The WBS includes exactly 100% of the work defined by the scope of the problem and covers all conditions (external, internal and intermediate) in such a way that the process is completed. This is known as "*The 100% rule*" for building a correct WBS. In the present case, the State assigns to various administrative structures the implementation and management of specific administrative functions. Each of these functions is analyzed and decomposed in order to shape the directions of the activity of each particular administration - i.e. the set of processes that appear there.

The 100% rule is the most important principle in designing, decomposing, and building of the classification structure, and should be applied at each level of the hierarchy, with the sum of the activities at a subordinate level being equal to exactly 100% of the work represented by the structure. The structure should not cover any activity beyond the scope of the process, i.e. not more than 100%.

In addition to the 100% rule, it is important that there is no overlapping of the broad description of two or more elements of the structure, as this inevitably leads to duplication/redundancy of work or further dilution in terms of responsibilities and competence. It is also necessary that all elements of the structure are distinctively described and named. The *vocabulary* contains descent explanations on the scope of an item, of an element name, of the structure itself. This is also the initial stage in the work of a heterogeneous type analyzer, namely the so-called "*Alignment of concepts*" that is translating the terms between different functionaries. The structure terminology vocabulary describes all of its elements with their pre- and post-conditions, deliveries, activities, scope, and sometimes - dates, resources, cost, and quality metrics.

If the decomposition attempts to cover all activity-oriented details, the structure will contain too many or too few elements. Too many activities will surpass the 100% rule, while too few activities will be totally below the 100% demanded of the scope of the process. The best way to avoid this is to change the approach to the problem, i.e. to define the elements according to the results and not according to the activities required to achieve them.

The most important question that comes with the building of such a structure is when to stop the decomposition (*Degree of detail - the depth of decomposition*), or what is the basic structural element. In the case when administrative processes are described, a basic element of the structure can be a *document* or a *task*. With in-depth analysis and attempts to build functional structural descriptions (i.e. block diagrams and *Petri* nets), it appears that the document is by no means a basic element of the administrative-management process, as a task may arise from a document or as a result of another task, and the result of a task may be another task or document. I.e. depending on the aspect of analysis and modeling, it may be that "*document*" and "*task*" are the two basic elements of the classification structure, but in different situations one is subordinate to the other and vice versa.

So the *terminal element* is namely the smallest unbreakable element of the classification structure - an element that can not or needs not be subjected to further decomposition. Terminal elements are those components that are subject to evaluation in terms of resource requirements, budget and duration, and those that are subject to planning.

In these terms few remarks have to be made. The classification structure is a clear understandable description of the scope and the development of the process. The classification structure is neither a process schedule, nor a chronological description but its building should *precede* both the scheduling and the optimization. The opposite approach might be compared with making a construction's calculations after the construction has started.

WBS is not an organizational hierarchy, and mixing it with an organizational chart usually leads to some confusion and mistakes: while a certain activity / responsibility is assigned to a particular unit by the administrative structure, the WBS, describing the organizational structure, is not clear about the scope of the process, is not result-oriented but organization oriented. *WBS is not a logical model or a strategic plan*

The WBS and its formulation is the process of elucidating the structure of the process and its elements. Properly and appropriately formulated WBSs are a prerequisite for building a good model that allows for quality and efficient management and optimization of the process itself and the organizational structure itself.

3. Project management techniques in a determined case scenario

Project managers provide with two powerful tools for process management. In this section general idea of the Critical path method (CPM) and the Gantt chart are given.

The CPM or the critical path analysis is a mathematical algorithm for describing and planning a set of process activities. This is an important tool for effective project management and thus can be considered in social and economic processes.

It was developed in the 1950s by DuPont Corporation almost at the same time as the Program Evaluation and Review Technique (PERT) was developed in the US Navy. Any project / process involving interdependent activities/operations may be subject to this methodology.

The primary requirement to use CPM is to build a process model that includes the following elements:

- A list of all activities required to complete the process - usually categorized in the WBS
- Duration of each activity
- Dependencies between the activities

By using the above three, the method calculates the critical path from planned activities in order to complete the process along with the earliest and latest start-up moments, respectively completion of each activity, without affecting the time duration of the overall process. The CPM identifies which activities are "*critical*" (belong to the critical path) and which activities are "*floating*", i.e. their delay over time does not lead to prolongation of the overall process. In project management for techno-economic processes, the critical path is the sequence of activities that forms the critical (expected) duration of the process. Any delays in critical activity lead directly to postponing the moment when the process ends over time, that is, to a complete lag. A process may also have several parallel, near-critical paths. Such an additional parallel path whose overall duration is less than that of the critical one is called a sub-critical or non-critical path. Sometimes the term "*scenario*" is used instead of "*path*".

A main advantage of the method is that the CPM results allow managers to prioritize activities with a regard to effective project management and planning, and completion, trying to reduce the critical scenario of a particular process by reducing the critical activities. This is done through "*fast tracking*" that is the aim of performing more activities in parallel rather than successively and / or by "*crash critical path*" that is the aim to reduce critical activity time by adding additional resources.

Only the logical dependencies between the terminal elements were initially considered in the method. Subsequently, the method is extended to assess the resources needed for each activity. This extended model allows for the inclusion and the identification of delays that result from inadequate/insufficient resources (*bottlenecks*). This might result in a shortest path to become the longest by building a "*critical resource path*". The concept is called a "*critical chain*" and aims to protect the duration of an activity or the whole process from unforeseen delays in the resource constraints.

Since the actual schedule of the process changes over time (i.e. it is in dynamics), the CPM allows for a real-time tracking of the critical activities and alerts the managers of the risk of non-critical activities to be postponed after the available time slack, thus another critical path might emerge and then an additional time delay of the whole process to appear.

As the dynamic programming being in the basis of the CPM concept, the problem is solved iteratively into three main stages. The first stage is the *forward pass* of the network from its starting node to its terminal one. Let *i* and *j* denote any two nodes in the network model connected with an arc (*i*,*j*) with a given value for its duration D_{ij}. Let also ES_j is the earliest moment for the start-up of all operations that start from a node *j*. Then the earliest possible moment an event *j* to occur is evaluated with:

(1) $ES_j = \max\{ES_j + D_{ij}\}$, maximization over *i*

Let *i* are the preceding events that are connected to *j* via an arc. An initial condition $ES_1 = 0$ is included. Now also ES_j is the longest way from 1 to *j*.

In the second stage a *backward pass* is performed with the evaluation of the latest moment that an event *i* might occur, that is the completion moment of all operations/activities ending in the event *i*. So the latest completion time LC_j is:

(2) $LC_j = \min\{LC_j + D_{ij}\}$, minimization over *j*

Now all activities following the node *j* are observed that are connected to *i* via an arc. The initial condition is $LC_1 = ES_n$ where ES_n is the earliest time to reach the final event. An operation (*i*,*j*) is critical if:

(3.1) $ES_i = LC_i$

(3.2) $ES_j = LC_j$

(3.3) $ES_j - ES_i = LC_j - LC_i = D_{ij}$

The latest 3 expressions show that there is no time reserve between the moments of earliest start-up and latest completion. For each operation (*i*,*j*) four additional parameters should be determined: Latest Start time (LS_{ij}), Earliest Completion time (EC_{ij}) and two time reserves (also named *floats*): Total float (TF_{ij}) and Free float (FF_{ij}),

(4) $LS_{ij} = LC_{ij} - D_{ij}$

(5) $EC_{ij} = ES_{ij} + D_{ij}$

(6) $TF_{ij} = LS_{ij} - ES_j$

(7) $FF_{ij} = ES_j - ES_i - D_{ij}$

Again, an operation (*i*,*j*) is critical if it shows no time floats, that is $TF_{ij} = 0$. The critical duration (D_C) of the whole process is the sum of the durations of its critical operations D_{ij}^C: $D_C = \sum D_{ij}^C$ (8)

Another tool from Project management that is applicable to the administrative process management problem when the duration of the activities are considered constants is the *Gantt* chart. The Gantt chart is a diagram illustrating the *timing* of a process. It describes the start and end moments of the terminal elements as well as the summaries of a given process. Terminal and aggregate elements form the set of the process' structural elements. Some Gantt diagrams also represent the relationships between the various activities. In information technology, the Gantt chart can be also used to visualize the data collected so far.

Gantt charts are a widely used from practitioners in project management as a technique for presenting the phases (stages) and the distinct activities in a given process structure so that it is understandable to the general audience. A major mistake in constructing the Gantt chart is the mixing of the Gantt timeline and the process management, which is aimed at building the process structure along with the timing of the schedule of activities in the structure. Such an approach makes the compliance with the 100% rule very difficult. The sequence of modeling actions is as follows: firstly, the structure of the process should be built up and then comes the building of the activities schedule. It is also considered that a Gantt chart is a useful and valuable tool for small projects since its goal is primarily visualization and if the latter becomes difficult because of a project's size mistakes can occur.

4. Dealing with the uncertainty as a random variable

In this section, two approaches to deal with the uncertainty in the activities duration are reviewed: the Program (or Project) Evaluation and Review Technique (PERT) that treats the activities durations as random variables with a beta-distribution and an interval approach to an activity duration.

PERT

PERT is a model for analyzing and presenting tasks that are performed to complete a process, especially with regard to the time needed to complete each task and the definition of the minimum time required to complete of the whole process. PERT has been developed primarily to simplify the planning and scheduling of large and complex processes and provides a description of such technical and economic processes for which the duration of each activity is not *exactly* known. PERT can be considered as an "*event-oriented*" model, in which the duration of each operation is a random variable, in contrast to the Critical Path Method (CPM), where the weights of the arcs denoting the durations under consideration are constants. PERT and CPM however are applicable to a wide range of processes even administrative ones.

When building a PERT model few conventions should be observed. PERT is *a decision-making* tool so the first iteration of the chart gives a sequence of events and allows subsequent inclusion of additional ones. Two consecutive events in a PERT chart are linked through activities that are represented by arcs. Events are presented in logical sequence and no activity can begin *until* the previous event has ended. In is the designer that decides which elements are PERT events and defines their correct logical sequence. Also, a PERT chart can have multiple pages and multiple *sub-tasks*. With PERT, it is possible to manage processes in which there are multiple simultaneous (convergent and independent) tasks and also to perform a *reduction* of surpluses (redundancies) and repetitions. So in such approach, PERT is a *qualitative* description of a discrete-event processes under consideration that: *allows* optimization in the elimination of inverse and parasitic movements, *presents* the hierarchy and the mutual dependencies between the results of a stage and the beginning of the next.

Being a tool for project managers, PERT also has its own vocabulary. A PERT event is a point (*event, node*) marking the beginning or ending of one or more tasks (*activities, operations*). It does not consume time and does not spend resources. A PERT event simply denotes the completion of one or more tasks as it is not reachable until all activities leading to this event have been completed. So a PERT event might be also considered as a state flag.

PERT considers two types of events: a *predecessor event* that is an event (or a set of events) that precedes immediately another event (s) and it may be the result of more than one activity and a *successor event* that is an event (or a set of events) that follows immediately an event and it also may be the result of more than one activity. An activity denoted graphically with an arc in the underlying network model is the actual execution of an administrative task or activity. It *consumes* time and requires resources such as effort, work, labor, materials, space, equipment and qualifications, etc. A PERT activity can be approached from the points of view of time, effort, and resource requirements for going from one event to another (that is from one state to another). An activity can not be completed until its predecessor event has happened. If the event is considered as a state of an activity, the latter is expressed as: an activity can not start until all its predecessor activities are of a certain state that is completed.

As mentioned above, in PERT, the time required to complete a certain task is considered as a random variables. So for the duration of each operation PERT makes certain assessments. The time required to complete a task is considered as a beta-distributed random variable. So there is an optimistic time (*a* - the minimum possible time required to complete a task with the optimistic assumption that everything happens better than it is actually expected), a pessimistic time (b - the maximum time it takes to complete a task, assuming everything that might go wrong actually goes wrong, without taking into account any *force-majeure* events) and a most likely time (m - the most realistic estimate of the time required to perform a task under normal circumstances). While considering a normal distribution, the most likely time will be the mean value of the random value distribution. In PERT it is assumed that the random duration of each operation is described by beta-distribution (symmetrical or asymmetric).

Assuming a random variable distribution a mean value and variance might be obtained having in the mind that the extremes of many probability distributions lie about three standard (mean square) deviations 3σ from the mean [7]. In our case, the average is the so-called "*expected time*" ($\overline{D}_{ij}$) and this is the best estimate of the time required to complete a task under normal circumstances. The addition here is that the expected time is the average time that requires a task if the task itself repeats over time in different conversions over a long period of time. The expected time is a statistical measure.

A *float* is the time reserve. This is the amount of time that can a task start be postponed without causing delays for subsequent tasks or the whole process. Therefore any activity with a zero-valued float is critical. A critical path is the sequence of activities with zero floats thus forming the longest possible journey from the start to the final event and it determines the total time needed to finalize the process. For this reason, any delay in the critical path inevitably leads to delays in the whole process.

Lead time is the time during which a predecessor event must be completed to provide sufficient time for all activities before a particular PERT event is completed. On the other hand, a lag time presents the earliest moment that a successor event may follow after a PERT event.

Another interpretation of the floats is that a *slack* is the measure that denotes the surplus / reserve of available time and resources (overwhelming) when an event is realized. Positive slack indicates ahead of schedule - before schedule; negative slack indicates a delay that is behind schedule and a zero slack indicates on schedule.

As mentioned before, project managers generally stick to two basic ideas for projects overall duration reduction that are *fast tracking* (parallel critical activities execution) and critical path *crashing* (adding resources to critical activities in order to shorten their duration).

Building a PERT chart and finding a critical path can be seen as an inverse problem for the shortest path in an uncertainty network in the following steps: identify all activities, define the appropriate consequence of actions, build the network model, evaluate times for every activity and define the critical path

The only difference with the CPM is that the "*expected time*" measure for the activities duration is used instead of its determined case analogue. The overall duration of the critical path is again the sum of all expected durations of the activities in the critical set. And a mean variance is also available. These assumptions also apply for a shortest path problem. So from such perspective, the critical path presents the longest run and its duration is a sum of random variables so it is also a random variable with a distribution close to normal.

Interval approach to uncertainty

As a rule, in case of uncertainty the values of the parameters of a model are far from accurate. Generally, however, these values can be included in intervals [a, b] respectively with lower a and upper b bounds [8]. The average of the duration interval for each operation is then determined with simple averaging:

(9) $$m = \frac{a+b}{2}$$

Then the half width Δ of the duration interval for each operation can be s determined with:

(10) $$\Delta = \frac{b-a}{2} \quad \text{so that} \quad a = m - \Delta, \quad b = m + \Delta$$

Again, the mid-point of the interval in which the critical path's duration is expected to fall is the sum of the mid-points points of all intervals of the operations on the critical path, and its half-width is the sum of all critical path's activities half-widths. Finally, the upper and lower bounds of the critical duration's interval are determined by the second part of the expression (10) and the same reasoning applies to the shortest path in the network.

5. Conclusion

Gantt charts represent only a fraction of the triple limitations (cost, time, and scope) of a process, as they focus on managing the time plan. Moreover, they do not represent the scope of the process or the relative scope of the elements. If two projects have the same number of days left behind, the larger project reflects at a greater power on spending and resource utilization, something that remains invisible in a Gantt chart. With this chart, optimization of operations, time and resources is difficult to achieve, and even if it is done, it is usually based on heuristic or intuitive techniques that are closer to CPM and PERT. For these reasons, the Gantt diagram of the administrative process can be used only to illustrate the time plans. A PERT approach is a network-based model of the process. Its visibility and accuracy are in direct relation with the correct and accurate definitions and decomposition of phases and stages in the WBS. PERT also provides for the analysis of processes with statistical uncertainty, obtaining statistical assessments and the human resources management. The introduction of administrative processes management algorithms aims to reduce the probability of errors and decreasing the total time for the rendition of a result from an administrative service thus guaranteeing the required implementation quality and timely for the administrative management functions, and sometimes followed by an overall costs reduction.

6. Bibliography

[1] A guide to the Project Management Body of Knowledge (PMBOK guide), Project Management Institute; 5th ed edition (1 Jan 2013), ISBN-13: 978-1935589679, 592 pages

[2] Hillier F.S., Lieberman G.J., Introduction to Operations Research, 9th ed. , McGraw Hill, ISBN 978-0071333467, 2013

[3] Гатев Г., Изследване на операции, Избор на решения при определеност, 2005 г. ISBN 954-438-089-2

[4] Trashlieva V., Puleva T., Model Building for Optimal Administrative Process Management, International Conference "Automatics and Informatics" 2011, 03-07 October 2011, Sofia, Bulgaria

[5] Антонов А.В., „Системный анализ”, Высшая школа, Москва, 2004, ISBN: 5-06-004862-4, 454 стр.

[6] Баринов В.А., Болотова Л.С. и кол., „Теория систем и системны анализ в управлении организациями: Справочник”, изд. „Финансы и статистика”, Москва, 2006, ISB N 5-279-02933-5, 846 стр.

[7] Kazmier L.J., Schaum's Outline Theory and Problems of Business Statistics 4th ed., McGraw Hill Professional, 2004, p. 359, DOI 10.1036/0071430997

[8] Гео Гатев, „Подход на интервалния анализ и алгоритми за решаване на мрежови задачи на динамичното програмиране при параметрична неопределеност”