Time, Knowledge and Projects

Antonio Lentini

Email: antonio.lentini@schindler.com

Abstract

One of the main concerns of project managers is to keep their projects on schedule. The difficulty to manage projects duration may be mitigated thanks to the understanding of the nature of time and through the application of the physics theories which explain that time as an independent concept has no place in physics. This paper presents a project management methodology, called Project Network Knowledge (PNK), which aims to better support projects planning, monitoring & control, and closure. The methodology is derived from Julian Barbour's expression of time provided in his essay [1], and from the definition of information, knowledge and knowhow given by César Hidalgo in his book [2].

1 Introduction

"The biggest challenge to delivering projects on time is people." So told me an experienced project manager several years ago, while he was quietly monitoring the controlled chaos of an active construction site.

"The biggest challenge to delivering projects on time is that time does not exist and people keep ignoring the physics theories which explain that at a foundational level the universe is static." So commented a young physicist when I reported to him the statement of the long-tenured professional. At that time, I thought that the expert of physics was just joking.

May be both the project manager and the physicist have a point? Nowadays, I tend to think so.

2 Time and Projects

A widely well-accepted methodology to plan a project is derived from PMI PMBOK standards [3] and it identifies the following 24 processes:

1. Develop Project Management Plan
2. Plane Scope Management
3. Collect Requirements
4. Define Scope
5. Create Work Breakdown Structure (WBS)
6. Plan Schedule Management
7. Define Activities
8. Sequence Activities
9. Estimate Activity Resources
10. Estimate Activity Durations
11. Develop Schedule
12. Plan Cost Management

13. Estimate Costs
14. Determine Budget
15. Plan Quality Management
16. Plan Human Resources Management
17. Plan Communication Management
18. Plan Risk Management
19. Identify Risks
20. Perform Qualitative Risks Analysis
21. Perform Quantitative Risks Analysis
22. Plan Risks Responses
23. Plan Procurement Management
24. Plan Stakeholders Management

According to this methodology, the project scope, WBS and activities are static, i.e. independent from time. Only once the activities have been defined, the idea of time appears for the first time within the process "Sequence Activities". So, we can identify dependencies like "Activity B cannot start unless Activity A has finished" only after that the activities are defined. This is substantially consistent with Barbour's statement that time starts to exist only when motion (i.e. activity) does.

The second process that involves time is "Estimate Activity Durations", which follows the process "Estimate Activity Resources". It means that the experts can estimate the duration of the identified activities only after that the project's resources are estimated. In other words, durations depend on the people allocated to the activities; therefore, time is relative to interactions among people. Again, although we normally tend to consider project time as absolute, this methodology is surprisingly in accordance with Barbour's idea of time regarded as an abstraction from motion.

While the methodologies derived from PMI PMBOK standards focus on estimating activities durations using information on activity scope of work, required resource types, estimated resource quantities, and resource calendars, the proposed methodology will focus on the interactions between the resources and on their computing ability.

3 Critical Path

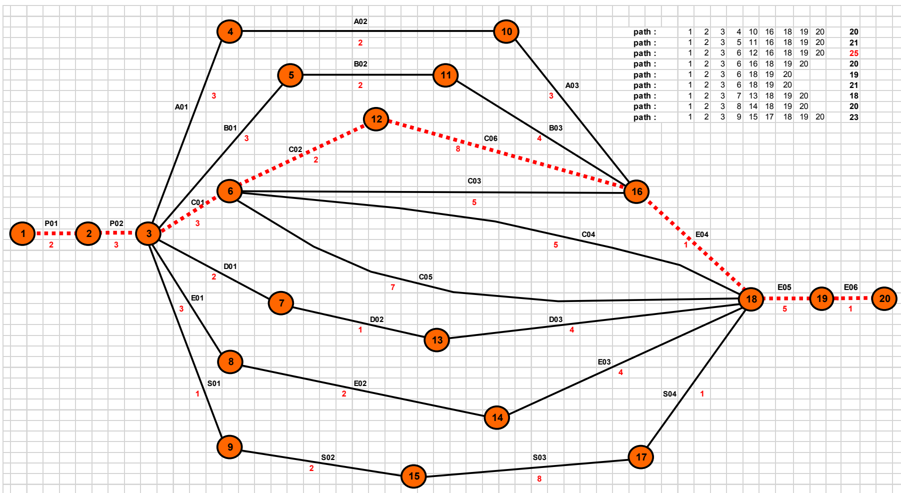
The processes listed above to plan the project scope and time management allow using the Critical Path Method (CPM) to determine which activities cannot be delayed without impacting the overall project duration. Project managers using CPM construct a model of the project that includes the following:

1. A list of all activities required to complete the project, typically categorized within a work breakdown structure
2. The duration that each activity will take to complete
3. The dependencies between the activities and
4. Logical end points such as milestones or deliverable item.

Using these values, CPM calculates the longest path of planned activities to logical end points (milestones) or to the end of the project, and the earliest and latest that each activity can start and finish without making the project longer. This process determines which activities are "critical" (i.e., on the longest path) and which can be delayed without making the project longer.

But how to improve the accuracy of the estimation of the durations on the critical path?

Figure 1. Example of critical path analysis. The combination of the activities on the red path cannot be delayed without making the project longer



4 Projects Are Networks

In order to proceed with the quantification of the project durations, I need first to summarize some basic definitions provided by C. Hidalgo in [2].

a. Information is an indicator of the order of a system

b. Information is *physically embodied*: objects embody both mass and information

c. Knowledge involves the relationships or linkages between entities

d. Knowhow is different from knowledge because it involves the capacity to perform actions. Knowhow is the tacit computational capacity that allows us to perform actions, and it is accumulated at both the individual and collective levels

e. Unlike information, knowledge and knowhow are *embodied in humans and in network of humans*

One fundamental assumption of this work is that information embodied in objects and the knowledge and knowhow embodied in humans obey to the same laws that are valid for the mass embodied in objects.

I found an unexpected support to this assumption in an elaboration of Rupert Spira [4], who said: *“The laws of physics are not in fact laws of physics, they are the laws of mind.*

We only think they are the laws of physics 'cause in our culture we still believe in material stuff called matter. In fact, there is no material stuff called matter, it's all mind. That doesn't mean that the laws of physics are nonsense, it's just that they attain to the patterns and habits that govern the unfolding of mind rather than the behaviour of matter.

So, this unfolding of mind proceeds in an orderly fashion through a series of laws through which consciousness is progressively narrowed until it appears as the material world."

To apply the methodology proposed in this paper it is not necessary to assume that there is no matter and that it's all mind. It is enough to consider as true that the laws of physics attain to the patterns and habits that govern the unfolding of information rather than the behavior of matter.

This unfolding of information proceeds in an orderly fashion through a series of laws through which *knowledge* is progressively narrowed until it appears as the material world *in objects that physically embody information*.

So, let's assume that the laws of physics describe the unfolding of information in a system: the matter is information embodied in objects, knowledge is information embodied in individuals and in network of individuals, knowhow is the capacity to perform actions which transfer information into objects. This assumption allows me to apply the equations presented in [1] to the problem of the project duration calculation. Let's define a project team as a network of individuals who are processing information to produce a well-defined and measurable output. The project members are the nodes of the network. In order to quantify the knowledge and knowhow of the network, we need to consider the project network of individuals as an isolated system. This premise can be considered true as long as the stakeholders are identified and included in the project network and the stakeholder's analysis is updated often enough to ensure that the boundaries of the isolated system are valid. In fact, a project team is a complex adaptive system and its boundaries are dynamic. The project manager is responsible to manage the variable links among the nodes and the inclusions and exclusions of the project stakeholders. If the assumption that the project network can be considered an isolated system is valid, I define the kinetic energy T of the project network as a measure of the quantity of information transferred into matter. T is a function of the sum of knowhow of the project nodes. In a similar way, I define the potential energy V of mutual interacting project members as a measure of the quantity of information not yet embodied in matter. V is a function of the sum of knowledge of the project nodes.

The energy T + V of an isolated project network remains exactly equal to a constant E in time. In [1] the energy conservation is expressed by the following equations:

$$V = -G \sum_{i<j} \frac{m_i m_j}{r_{ij}} \quad (1)$$

$$E = T + V = \sum_i \frac{m_i}{2} \left(\frac{\delta d_i}{\delta t}\right)^2 - G \sum_{i<j} \frac{m_i m_j}{r_{ij}}. \quad (2)$$

In equations (1) and (2), G is a constant, m_i is the output of the project member (or node) *i* in the project network, r_{ij} is the distance between nodes *i* and *j*. The summation symbol with *i* < *j* under it means take all pairs *ij* once, calculate $\frac{m_i m_j}{r_{ij}}$ for each, and add them all together. δt is the increment of time between two milestones on the same path, d_i is the increment of distance between two milestones on the same path provided by the project node *i*. For one of the trial paths the action will be smaller than for any other: this trial path is the critical path. For this extremal curve, and in general for no other joining the fixed end points, according to the herewith proposed model the project duration obeys time law defined by equation (3) in [1]:

$$\delta t = \sqrt{\frac{\sum_i m_i (\delta d_i)^2}{2(E-V)}}. \quad (3)$$

I stress that *only for the activities on the critical path* we can define the duration between two adjacent milestones with equation (3). The durations for other, non-critical paths, are governed by a similar equation, but their values of m_i, E, V differ from the values for the critical path. People tend to apply all their knowledge and interaction only to those activities, which cannot be delayed without making the project longer. The other activities are executed at a lower rate or by less skilled and experienced people.
Equation (3) tells us that, in order to reduce the activity duration δt we need to minimize the contribution of the project network nodes to $\sum_i m_i$ along the distance δd_i and to maximize the difference T = (E-V). It means that we have to transform as much as possible the knowledge V of mutual interacting project members into physical output.
The residual potential energy V that is not converted into physical output is *a waste and a limiting factor* for the reduction of the activity duration δt.
The fact that we need to minimize $\sum_i m_i$ in order to reduce the duration is in accordance with the formula to calculate the number of communication channels on a project, which is:

$$c = N(N-1)/2 \quad (4)$$

where c is the number of communication channels and N is the number of nodes of the project network. The greater is the number of communication channels, the greater is the sum of m_i and the activity duration δt.
One question rises now: how to calculate m_i and $\sum_i m_i$/2(E-V)?
m_i is the output of a node of the project network. We may describe a neuron *i* by writing the following equations:

$$a_i = \sum_{k=1}^{Nin} w_{ik} x_k + b_i \quad (5)$$
$$m_i = \varphi(a_i) \quad (6)$$

where x_k are the Nin input signals; w_{ik} are the synaptic weights of neuron *i*; b_i is the bias; a_i is the induced local field; φ (.) is the activation function; m_i is the output signal of the neuron.
In this model the mass of the node (i.e. its contribution to the network's output) is a function of the *knowledge previously embodied* in the node, its bias b_i, and of the *knowledge* exchanged with the adjacent nodes $\sum_{k=1}^{Nin} w_{ik} x_k$. Such knowledge is transformed into the physical output by the *knowhow function*, i.e. by the activation function φ (.).
So, $\sum_i m_i$ is the output computed by the project network. For example, a multilayer perceptron (MLP) network can model the project network and it can be trained to provide the output. It is out of the scope of this paper to explain how a MLP works. It is enough to

look at a simple architecture like the one presented in Figure 2 to understand that the calculation of $\sum_i m_i$ tends to become very complex when the number of nodes i increases.

Figure 2. Example of multilayer perceptron.

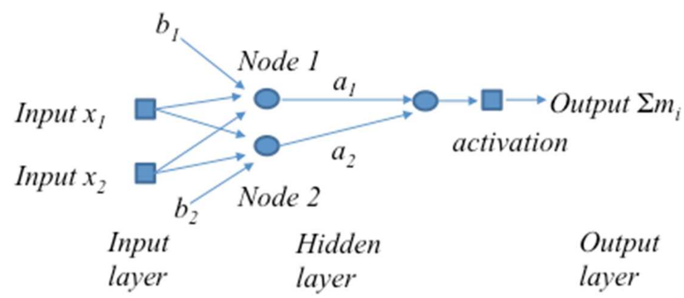
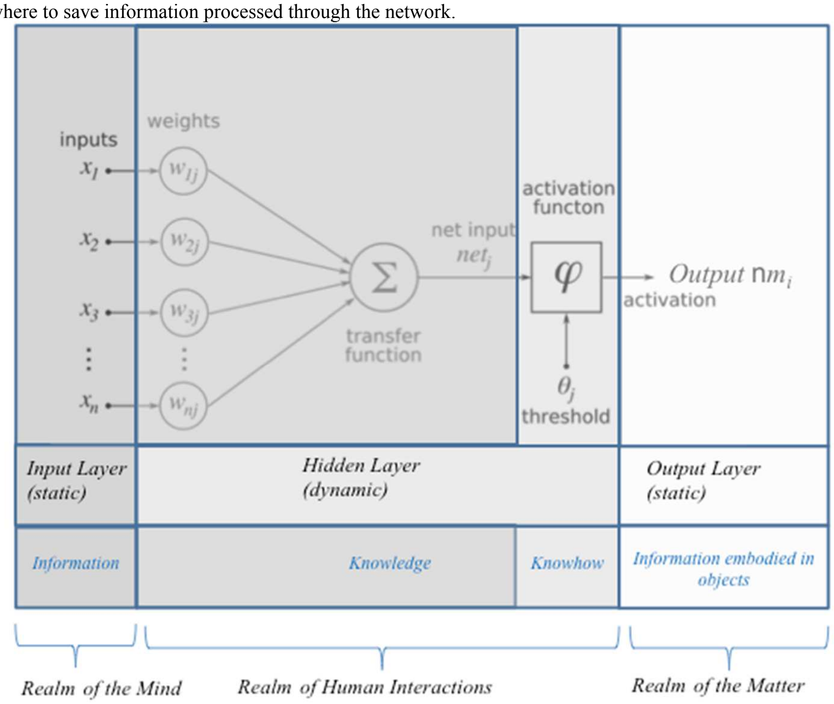


Figure 3. Representation of the transfer of information through the project network. Matter is the support mean where to save information processed through the network.



The problem of learning in neural networks has been formulated in terms of minimization of an error function of the adaptive parameters (weights and biases) in the network.
In order to proceed with the network's learning, it should be measured how much time δt a project network needs to perform the change δd_i from one milestone M_i to the next milestone M_{i+1} along the critical path. Equations (2) and (3) show that the experimental data (δt, δd_i) are a function of $\sum_i m_i$/2(E-V):

$$\frac{\sum_i m_i}{2(E-V)} = \left(\frac{\delta t}{\delta d_i}\right)^2 \qquad (7)$$

A collection of a whole set of experimental data (δt, δd_i) can be used to train a multilayer perceptron in a supervised manner with an error backpropagation algorithm to make the actual response of the network move closer to the desired response (δt, δd_i). A network is said to *generalize* when the input-output mapping computed by the network is correct (or nearly so) for test data never used in training the network. It means that when the learning phase is successfully completed, the neural network is able to provide with certain accuracy the time δt (output) that corresponds to the change δd_i (input).

5 Updated Planning Processes - PNK

This work proposes a new methodology, called Project Network Knowledge (PNK) to plan a project, which identifies the following 26 processes:

1. Develop Project Management Plan
2. Plane Scope Management
3. Collect Requirements
4. Define Scope
5. Create Work Breakdown Structure (WBS)
6. Plan Schedule Management
7. Define Activities
8. Sequence Activities
9. Quantify the amount of kinetic energy T which is needed to complete activities on every path
10. Define the network architecture (number of neurons and their relationships)
11. Train the network with a set of experimental data δt and δd_i measured on every path
12. Estimate Activity Durations on every path as a function of the output of the network
13. Develop Schedule
14. Plan Cost Management
15. Estimate Costs
16. Determine Budget
17. Plan Quality Management
18. Plan Human Resources Management
19. Plan Communication Management
20. Plan Risk Management
21. Identify Risks
22. Perform Qualitative Risks Analysis
23. Perform Quantitative Risks Analysis
24. Plan Risks Responses
25. Plan Procurement Management
26. Plan Stakeholders Management

Point 11 is key for the quantification of the durations. Usually the project team is defined and then put to work together on the project scope with given deadlines. There is no or little time allocated for experiments, as such a time is often considered a waste. In fact,

the time invested during the project planning phase to assess how people work together to process information is not a waste, it is essential to the success of the project.
During the project planning phase, a set of so-called safe-to-fail experiments, see [5], should be planned and the corresponding δt and δd_i should be collected to train the network.

6 Updated Monitoring & Control Processes - PNK

The network's architecture needs to be reassessed and readjusted during the monitoring and controlling phase of the project. Tools like [6] can be used to support the quantification and visualization of the interactions between the project team members. Such tools for example can track the number of emails, face to face meetings, videoconferences and phone calls used to exchange and increase knowledge among the collaborators.

Figure 4. Representation of a network of 15 collaborators and their interactions during the Project Planning Phase.

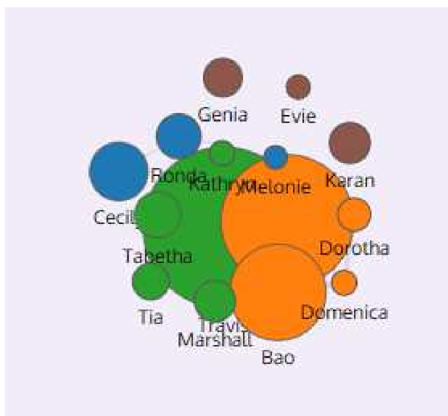
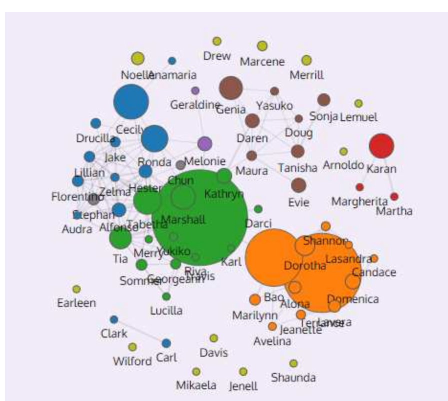


Figure 5. Representation of the same network during the Project Execution Phase. The top 15 collaborators interact with several Stakeholders.



The Monitoring & Control processes of the methodologies derived from PMI PMBOK standards [3] consist of the following 11 processes:

25. Monitoring & Control Project Work
26. Perform Integrated Change Control
27. Validate Scope
28. Control Scope
29. Control Schedule
30. Control Costs
31. Control Quality
32. Control Communications
33. Control Risks
34. Control Procurements
35. Control Stakeholders Engagement

This work proposes a new way to apply the tools and techniques of the Control Schedule process:

1. In order to optimize the resources, control the amount of kinetic energy T which is needed to complete activities on every path
2. Track, review and report the network architecture (number of neurons and their relationships) during the performance reviews
3. Train the network with an updated set of experimental data δt and δd_i measured on every path to create new schedule forecasts

7 Updated Closing Processes - PNK

During the project closure phase, it is a good practice to collect the lessons learned. Unfortunately, this process often has limited effectiveness, due to the fact that it is difficult to quantify the increase of knowledge and knowhow of the project members during the project's phases. The PNK project management methodology proposed in this paper simplifies the way to collect the lessons learned information to be transferred to the lessons learned knowledge base for use by future projects, as during the project closure it just requires the collection of the final values of $\sum_i m_i$, T and V.

8 Conclusions

This work shows how, under certain assumptions, the durations of the activities on the critical path are related to the knowledge of the project stakeholders and to their capacity to use their knowledge to perform actions. The stakeholders are the nodes of a network in continuous evolution. The problem of estimating the project's durations becomes the problem of estimating project's know-how and knowledge contributions of the network's nodes. In addition to the benefits deriving from a better estimation of the durations of the activities and from a fact-based allocation of the human resources, the proposed PNK methodology can provide the employees with an increased leadership and self-awareness of the knowledge and knowhow developed during their professional interactions.

References

[1] Julian Barbour ,"The Nature of Time" , 2008
http://www.platonia.com/nature_of_time_essay.pdf
[2] César Hidalgo, "Why Information Grows: The Evolution of Order, from Atoms to Economies", 2015
https://www.amazon.com/Why-Information-Grows-Evolution-Economies/dp/0465048994
[3] Project Management Body of Knowledge (*PMBOK® Guide*)—Fifth Edition
http://www.pmi.org/pmbok-guide-standards/foundational/pmbok
[4] Rupert Spira, "Time and Objects are Co-created", 2015
https://www.youtube.com/watch?v=fr8WW_MPNBY
[5] Cognitive Edge, Safe-to-Fail Probes
http://cognitive-edge.com/methods/safe-to-fail-probes/
[6] Immersion, a people-centric view of your email life
https://immersion.media.mit.edu/

About the author

Antonio Lentini, Schindler Supply Chain Europe

Antonio Lentini holds a Master of Science degree in Aerospace Engineering from the university Politecnico di Milano. He is a Project Management Professional (PMP®) and a member of the Project Management Institute – Northern-Italy-Chapter (PMI-NIC) since 2014.

After an experience as a researcher within the framework of a Marie Curie project at the Department of Mechanical Engineering of the Instituto Superior Técnico in Lisbon, he joined SiemensVDO and then Deutz AG. He is co-author of two scientific papers about Power-Hardware-in–the-Loop test systems and of four patents about the injection and combustion electronic control in diesel systems.

Since 2006 he works at Schindler Supply Chain Europe, where he was engaged in several large projects (World Trade Center in New York City, Dubai International Airport, Incheon International Airport). Actually he is responsible for the PMO and for the transformation program of the Schindler supply chain in Europe.