ACTOR-BASED SIGNPOSTING: A MODELING TOOL TO IMPROVE THE SOCIO-TECHNICAL DESIGN PROCESSES

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Abstract

Socio-technical aspect of engineering design is an inter-disciplinary domain, an integrated organization of human- and non-human interactions. Modeling socio-technical design processes can therefore be influenced not only by the complexity of technical decisions, but also by that of social interactions. This paper is dealt with design process improvement through modeling and management of complexity and uncertainty, which is mainly associated with activities' and actors' behavior and multiple types of interactions among them. Hence, a modeling tool is proposed, by making a balance between detailed rigor nature of dynamic task models and the flexibility and abstraction of social networks models, so-called "Actor-Based Signposting" (ABS). We aim to come up designers and design managers with a guidance on not only the content of the work, but also on the way to carry it out, acting as an information mechanism to facilitate communication. A flexible and scalable simulation tool presented and exemplified in support of ABS system, which can be adapted to any kind of design processes.

Keywords: Design process, Process modeling, Simulation, Uncertainty, Communication

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Please cite this paper as:
Surnames, Initials: *Title of paper*. In: Proceedings of the 20th International Conference on Engineering Design (ICED15), Vol. nn: Title of Volume, Milan, Italy, 27.-30.07.2015

1 INTRODUCTION

Designing the socio-technical design processes (STDPs) contains the characteristics of both complex physical-technical system of design activities and the networks of interconnected actors (De Bruijn and Herder, 2009). In the light of current market pressure, managers are more curious than before to have a continuous improvement on their processes, but it is no longer useful the advancement in the technical systems, and the entire process instead should be viewed from a collaborative perspective. To this target, there is a long history of modelling efforts in the field of design processes (DPs), and from different facets. The reason for this variety may be laid on poor understanding on the behavior of a DP, i.e., unpredictable behavior between interconnected actors; the companies are hence looking for such efficient tools to deal with this ever-increasing uncertainty. Given a socio-technical system of activities, the collaboration and coordination among organizational network is a critical issue, because the way by which actors interact can heavily affect the behavior of entire process.
This paper aims to support managers and decision makers with an effective tool for their STDPs. We do this by shifting the modeling paradigm from design activities to the designers, with the specific focus being cast on their interactions structure and mutual influences. We aim to come up designers and design managers with guidance on not only the content of the work, but also on the way to carry it out, and acting as an information mechanism to facilitate communication.
The paper is dealt with DP improvement through modelling and management of uncertainty, which is mainly associated with actors' behavior and multiple types of interactions among them. Doing this way, a new version of Signposting system will be presented, by making a balance between detailed rigor nature of dynamic task models and the flexibility and abstraction of Social Networks models, so-called "Actor-Based Signposting" (ABS). We aim to extend the modeling paradigm from management and control of a large amount of activities in a complex system to the creation of a set of rules and hints for the actors that are involved in process. The model will be implemented through a simulation tool, while further discussion is made to verify the benefits behind the model use. The following of the paper is organized as follows: Section 2 provides a theoretical foundation on the contribution. Section 3 investigates the modelling challenges facing DP improvement. In section 4, the proposed modelling framework is presented, and its overall mechanism is outlined. In section 5, the model will be implemented and analyzed by a simulation tool, given some managerial implications. Finally, the paper is concluded in section 6 with some remarks on DP improvement.

2 THEORETICAL FOUNDATION

This section presents the preliminary of DP improvement, and overviews the difficulty of modelling STDPs, with respect to the literature.

2.1 Socio-technical aspect of design processes

Socio-technical aspect of design processes is an interdisciplinary domain, an integrated organization of human- and non-human interactions. It is not just social and technical systems side-by-side but is the whole unit, and must be able to close the gap between social needs and technical performance (Whitworth, 2009). Studies on STDPs accordingly turned around the objective of collaborative construction of the entire system, by highlighting the mechanism of interactions and communication between product, process, and organizational components.
For example, De Bruijn and Herder (2009) addressed different ways of integrating system- and actor-perspectives within a socio-technical design system, and investigated their multiple forms of combination. It was concluded that full integration is not always the preferred way, because actors are reflective and should be used alongside each other. Furthermore, Lu et al. (2000) presented a socio-technical framework to understand the relationships among the design 'process' and design 'conflict', by identifying the interdependencies among design tasks. The belief was that collaborative design activities are affected not only by technical decisions, but also by the social interactions.
Form socio-technical viewpoint, the overall behaviour of DP is tied up with the behaviour of actors involved. However, much focus of research until now was mainly on the quality of interacting (through increasing the individual's ability), and not much is known about the configuration of design teams to increase the process productivity, in spite of some efforts (e.g., Maier et al., 2012).

From the perspective of this paper, as is shown in Figure 1, complexity of STDPs is depended on multiple types of uncertainties come from the actors' behaviour (e.g., beliefs, interventions), and the structure of interactions among them (e.g., negotiation process, coordination mechanism), which can constitute the organizational structure. Therefore, an important step for effectively improvement of STDPs is to determine how multiple types of uncertainties (associated with design activities and actors) can affect the overall process behaviour.

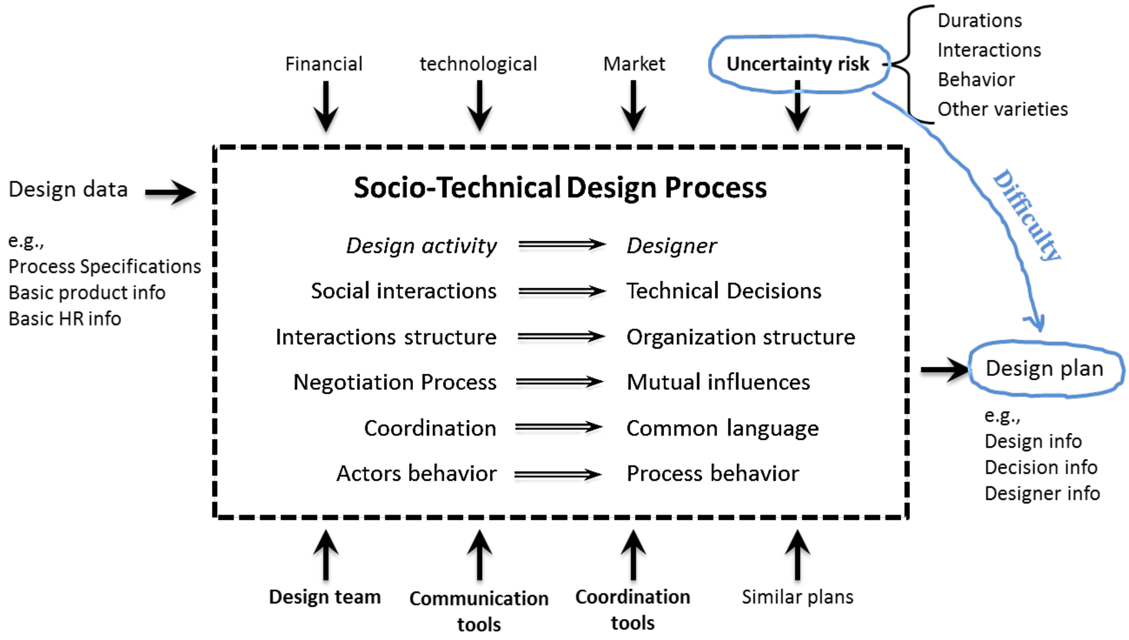


Figure 1. Design process as a socio-technical system

2.2 Similar tools for design process improvement

The typology of DP modelling tools is vast, while each one can be characterized by strengths and weaknesses. Some previous attempts in dealing with uncertainty of DPs are reviewed in this section, which distinguished to be more relevant to our contribution. In the domain of concurrent engineering, recent advances in modelling that face *overlapping* attempted to deal with uncertainty of PDPs, with the intent of improving project performance (Yang et al., 2012). Thanks to its flexible construct, *Petri-Net* is a graphical network of activities that is mainly used to model precedence in DPs. A timed colored Petri-Nets (PWF-nets) presented by Ha and Suh (2008) to deal with dynamic and uncertainty of PDPs, where they established their model on a class of predefined patterns: sequential, overlapped, iterative, coupled, split, and Join.

DSM family is another widely used approach for DP improvement, a distinguished representation tool for mapping information dependencies. Danilovic and Browning (2007) developed a systematic approach for the combinatory use of DSM and DMM for product development processes. The goal was to provide a holistic decision-support tool for managing the source of complexity and uncertainty in PDP projects. To this goal, they defined five interdependent domains: goal, tool, organization, product, and process.

This paper is concerned with the *dynamic* modeling of DPs (examples of dynamic tools are; ATP, Signposting). In general, these tools aim to outcome a sophisticated sequence of activities based on their information input and output characteristics. *ATP* (Levardy and Browning, 2009) assumed that product performance could be represented as a vector of attributes, so the modeling carried out through a number of alternative modes for an activity. *Signposting* (O'Donovan, 2004) is a parameter-driven technique, with the concept of 'current confidence' in the heart, as an indicator of the parameter state. Applied Signposting Model (ASM) presented by (Wynn et al., 2006) in support of DP improvement, through process description, simulation and automation. In terms of process description, a robust hierarchical structuring network proposed for activity sequencing, iteration and their multi-type interactions. Nonetheless, more detailed versions of these tool might be led into more complex systems of design activities, and therefore more difficult to manage all activities during execution.

3 COMPLEXITY OF MODELLING SOCIO-TECHNICAL DESIGN PROCESSES

Complexity, in general, is something that is made up of (usually several) closely connected parts. In engineering design, complexity is characterized by the (amount, and variety of) information and connectivity (e.g., interaction, collaboration), which are associated with dynamic state of the process. The complexity of design can be stem from the complexity of product, process or a problem (Ameri et al., 2008). This paper is dealt with complexity of STDP, shaping both the technical and the social complexity of design 'process'. There are nonetheless six aspects of complexity regarded in this paper:

- *Entropy/disorder*; basically means the degree of disorder, and has information view on system.
- *Connectivity/interaction*; is a fundamental aspect of process modeling, as in the reality, DPs are usually connected through numerous relationships.
- *Vulnerability*; analogous to the work by El-Haik and Yang (1999), the term vulnerability has three components in this paper: *dimension*, *mapping*, and *sensitivity*.
- *Communication*; is based on the belief that actors' behavior and power can affect the overall system complexity. These components are: *Negotiation*, *Position*, *Salience*, and *Influence*.
- *Dynamic behavior*; Behavioral or dynamic complexity exists if there are; multiple outputs for each activity input, multiple direct/indirect dependencies between activities, or obvious interventions that produce nonobvious consequences (Senge, 1990).
- *Uncertainty*; is recognized as a common measure for degree of system complexity. Regardless of its types, uncertainty can be originated from lack of knowledge on an issue, or from the variety (unexpected events). In engineering design, uncertainty can influence the process behavior in different ways such as task duration, task sequencing, and task outcome, rework likelihood, resource availability, etc. (Nichols, 1990).

3.1 Uncertainty: Main cause of complexity

Numerous researches are available on dealing with uncertainty, and from different facets; however, according to Grote (2004), there are two mainstreams for management of uncertainty: minimizing uncertainty, and coping with uncertainty. The former considers the humans as risk factors who have to be restricted in their freedom. Although this approach might work well in the cases of small-scale companies; however, in large complex systems with higher degree of uncertainties, the system must be able to cope with uncertainty to survive. In this paper, we will distinguish the *technical* and *social* aspects of uncertainties, and will show that how these perspectives can affect each other during the model execution. Technical aspect of uncertainty therefore refers to "Parameter" and "Model" uncertainty, while the social aspect includes "Behavioural" and "Interactions" uncertainty.

- **Parameter uncertainty** refers to definition, value, and dependency of a parameter with respect to other parameters. It is mainly due to imprecise definition or strong inter-relationships between parameters in the DP. In relation to the value of parameters, variation and immeasurability (vagueness) might be other causes of uncertainty.
- **Model uncertainty** refers to the amount by which the true value of a design variable differs from the value that computed for it (Fernandes et al., 2014). Herein, model uncertainty is viewed from two informational and physical aspects, respectively as data and structural uncertainty.
  - *Data uncertainty*: comes from three major sources: incomplete information, abundance information (data complexity), and errors. Errors are further separated to influence exchanging of information, and can be acknowledged (systematic) or unacknowledged (random).
  - *Structural uncertainty* reflects the concept of DP, and usually arises from different work-units that are working (hierarchically) together in DP. The relationships between basic variables, and the way they affect process behavior are concerned as structural uncertainty.
- **Behavioral uncertainty**: The way that individuals behave. Four sources are presented in this paper to cover behavioral issues: confusion (indeterminacy), belief, decision confidence, and behavioral variability (ignorance, indolence, intervention). These factors will be formulated into the model through meaning of actors' confidences, which will be explained in the next section.
- **Interactional uncertainty** refers to the mechanism by which actors negotiate to find a design solution, and can stem from their organizational influence, negotiation power, salience, and conflict among them. Thus, four major types of interactions are defined as major social sources of uncertainty in our model, and are explained in the following subsection.

3.2 Interactional uncertainty from an expanded view

As mentioned, the interaction structure in this paper is consisting of four major classes in their nature, as is described in the following, while is demonstrated in Figure 2. These classes will be later suited into the model in section 4 through stochastic formulation of interactions.

- **Intra-interaction**; occurs between any two colleagues within the same discipline, i.e., between two designers in the operative level, or between two managers in the strategic level (Figure 2). Hence, unlike the interaction framework in the reference Felekoglu et al. (2013), it is not limited to the technical (operative) level. It is the most likely type of interaction, and often happens in a direct way, and sometimes terms as face-to-face interaction.
- **Inter-interaction**; occurs between two persons from different disciplines, but within the same managerial level. It might be the common way of interacting between departmental colleagues; thus usually happens in organizational (process) level, i.e. executive manager and a project manager. Inter-interactions play a significant role to achieve an agreement during negotiation process, since many design problems requires communication among departmental teams.
- **Hierarchical interaction**; refers to the condition that people from different managerial levels are interacted, i.e. project manager and designer, or R&D engineer and COO. The primary goal here, in the case of direct interactions, might be such a kind of inspections or performance assessment and usually done as a top-down procedure. The inverse down-top condition is right when solving a specific problem, or for example, updating the product/process specifications.
- **Influential interaction**; is the result of dominant behavior in interactions, and occurs frequently, especially during hierarchical-interactions. Following Figure 2, it is a one-side interaction that might be happened during any other types of interactions, e.g., an inter-interaction can also be the influencing one, while can be direct or indirect. It is weighted here to be the most important class of interaction that might alter the condition under which a design activity executes.

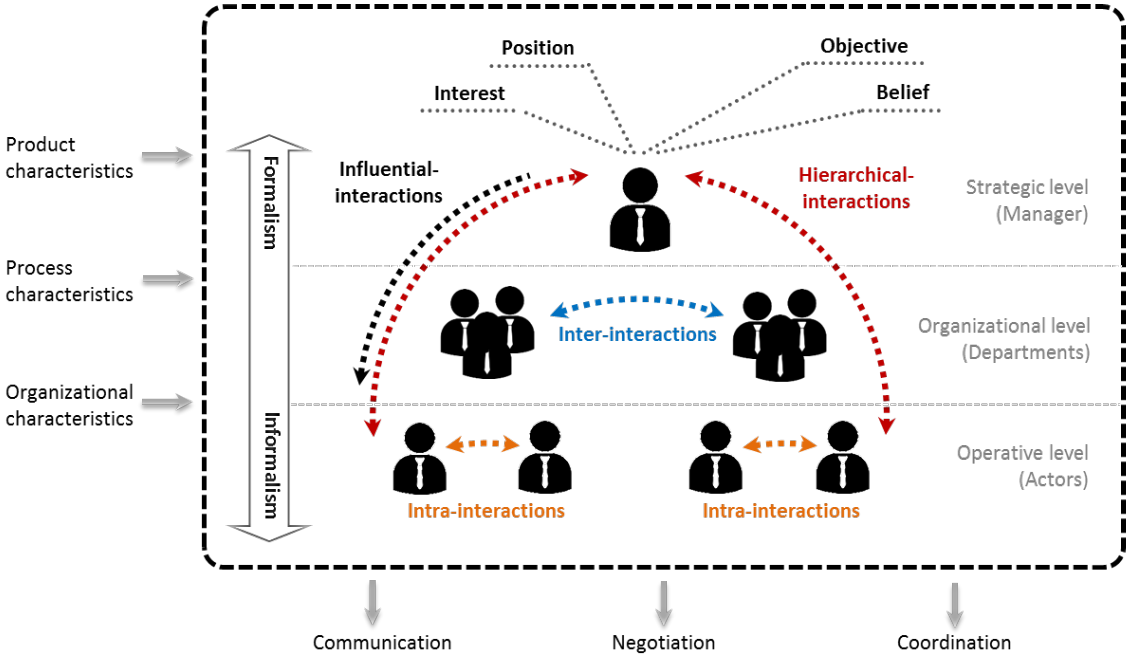


Figure 2. Interactions structure for a socio-technical design process

4 ACTOR-BASED SIGNPOSTING

The ABS model presented in the paper is based on a previous work by Hassannezhad et al. (2014) in which the well-known and widely accepted Signposting method (O'Donovan, 2004) was conceptually extended in order to capture and deal with uncertainties that caused by the social networks within DP.

4.1 Overview

The ABS technique intuitively "considers DP as the collaboration of actors with their corresponding activities and therefore views the process as a set of highly interconnected actors and activities with

interactions and reciprocal influences concerned with identification, estimation and iterative refinement of key design and performance parameters, until the best fit of actors-tasks are achieved, satisfying those parameters *confidence*". Confidence in Signposting is an abstract quality, which may take a number of meanings, typically referring to the designers' belief in their solution or some other aspect of design maturity (Wynn et al., 2006). It may be described qualitatively using parameter qualifiers (represented as numerical ordinal scales), or quantitatively using process variables (e.g., actor performance rate). Structurally, the core elements of ABS system are: parameters, states, tasks, and actors. Signposting is basically driven by *Parameters,* where the permission of either tasks or actors is issued based their confidence level on the system parameters. In ABS, parameters refer to any aspect of product, process, or the design organization.
The mechanism of ABS must act in order to allow actors to adjust their behavior. So the model should be more predictive rather than only describing the process state. This will be done through filtering alternative actors and tasks by assessing their both input and output requirements. Concerning the mechanism of actors' selection (i.e. based on the behavior and performance of actors), the ABS system might be knowledge-intensive. Therefore, it is recommended to combine the concept of Signposting confidence with an actor analysis tool, so-called Multi-issue Actor Strategic Analysis Model (MASAM) (Chea and Bui, 2004). Doing this way, a primary analysis of actors, and associated issues, is done, identifying the criticality of actors and associated issues (e.g., negotiation power, salience), which can complement the mechanism of actors' selection in ABS.

4.2 Task selection mechanism

Task selection is accomplished within two phases during ABS modelling; picking the precedent task (before execution), and assignment of the completed task (after execution). They are presented in Figures 3 and 4, respectively. The former phase starts with picking an initial task from the pool, and then, it is checked whether all precedent tasks for the selected task are completed (using *precedence parameter* in Precedence DSM). If so, the model searches for indirect dependencies between the picked tasks and the other ones (using *dependency parameter* in Task-Parameter DMM). Eventually, the task with higher degree of dependency, in comparison to the downstream task, will be selected and its total degree of dependency will be assigned as its "degree of criticality" (DoC).

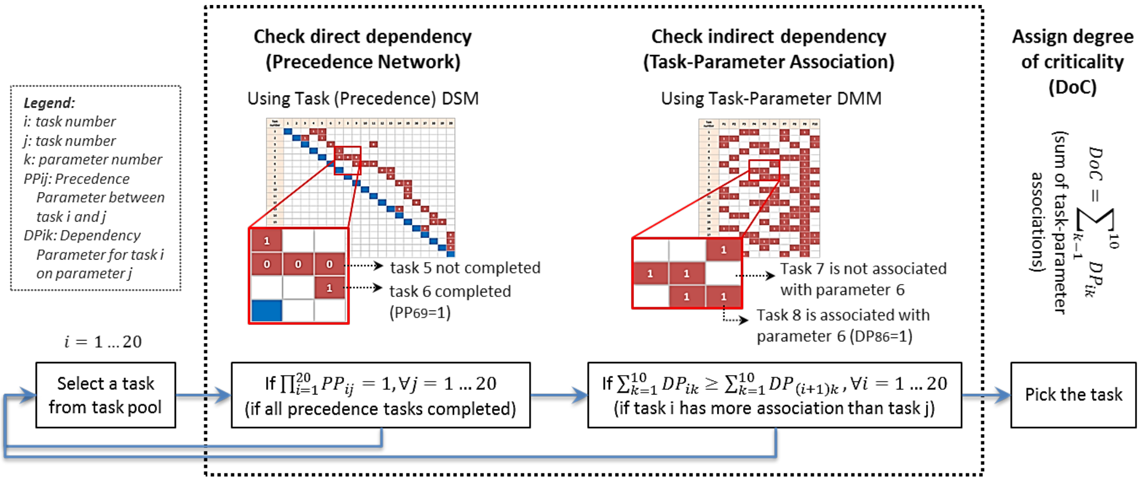


Figure 3. Task selection mechanism (before execution)

The second phase starts when the best alternative of actor is found and assigned to the picked task, and so the task is ready for the execution. In ABS, there are three output states generated randomly for each task. They check against the minimum confidence levels pertaining to the parameters that are associated with the task (using Task-Parameter DMM). If all confidence levels were greater than the minimum required ones, the difference between the output confidence levels and the minimum levels will be computed, so-called "Increment" in quality parameters. The task with the positive value of increment will be named as a successful task. In the last step, when three successful tasks achieved, the output state with the highest amount of increment will be selected. This multi-echelon procedure can ensure that design tasks implement at their highest level of quality, as a principle goal in the Signposting system.

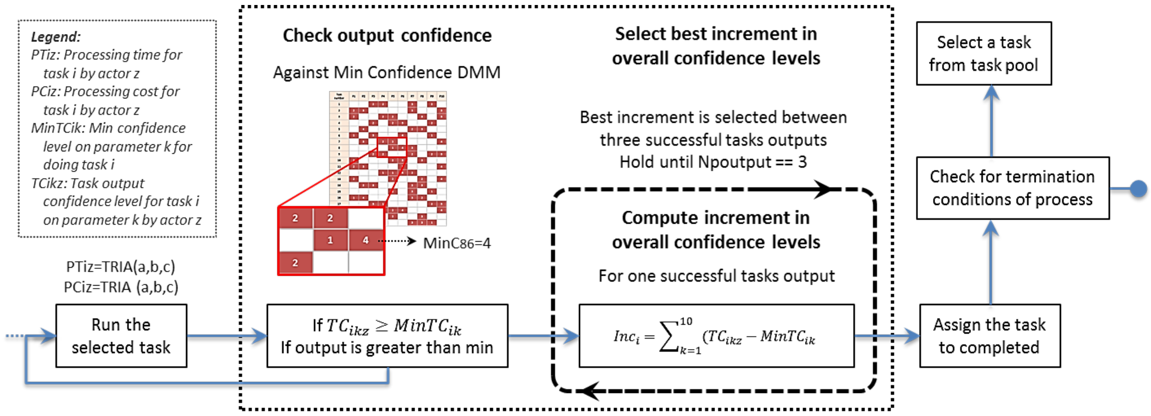


Figure 4. Task selection mechanism (after execution)

4.3 Actor selection mechanism

The term *actor* in ABS refers to any kind of stakeholder that has transaction with the DP. Previous versions of Signposting considered actor as audience of the model and in a more detailed manner, as a resource on the task mapping. Hence, the influence and power of people in design decisions would be missing. In ABS, the role and influence of actors are captured into the model under two circumstances; their behavior and interactions, and by using two sets of parameters: *behavioral* and *interactional* parameters (an example is shown in Figure 5). The former is used for initial actor selection, while the latter is used for assessing the mutual influences, and for finding the (final) influencing actor.

Table 1. Definition of qualifiers and associated confidence levels for behavioral parameters

Parameter		Independency	Persistency	Readiness	Flexibility	Education	Experience	Skilled
Weight		0,15	0,10	0,15	0,10	0,10	0,20	0,20
Confidence levels	**1**	Dependent	Inactive	Unavailable	Single-oriented	Diploma	Novice	Unskilled
	2	Trustable	Moderate	Accessible	Possessive	Bachelor	Junior	Certified
	3	Independent	Active	Available	Flexible	Master	Experienced	Specialist
	4	-	Hard-work	Ready	Multi-functional	PhD	Senior	Expert

During the initial actor selection, the model searches for all alternative actors associated with the picked task (using binary *Actor-Association Parameter* in Tasks-Actors DMM). Actors with positive value, in the same row of DMM, will then compare based on the sum of their confidence levels (AC_k) on the behavioral parameters. However, the prerequisite in this step is that they must satisfy the minimum confidence level associated with each task. Actors with similar value of AC will rank based on their performance rate (PR), which is a weighted vector that is rated based on our previous understanding of the personnel, subject to their salience, negotiation, and influencing power. This rate will dynamically change during the model implementation according to the positive or negative performance of actors. The goal of this stage is to find an actor that has the highest degree of qualifications (overall confidence level) on the work, and gives us an initial alternative for the task.
Upon the qualified actors is achieved, the next step is to investigate whether his/her interactions with other stakeholders can influence his/her performance. This would be done through a set of four interactional parameters (within four DSMs) that previously discussed in Section 3.2 (e.g., *Influence Parameter* for influential interactions). If the selected actor can be influenced by another alternative, the model checks whether the new alternative is eligible to execute the task (using Task-Actor DMM). The above mechanism eventually allows us to find out the most appropriate alternative for a given task, in the sense that cannot be influenced by other actors (during execution), while has a satisfactory degree of interactions with others, and is able to execute the task at the highest level of confidence.

4.4 Flexible rework policy

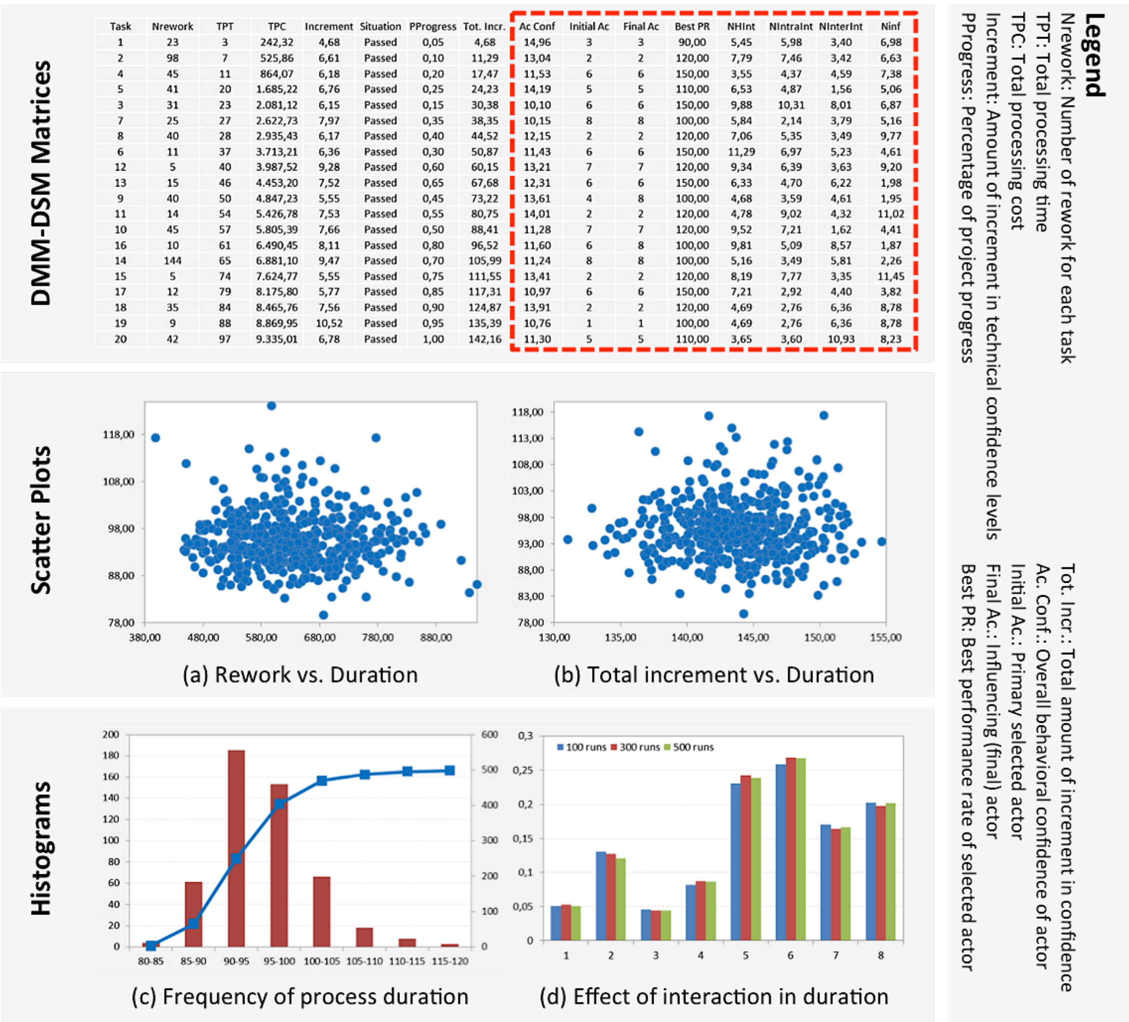
In order to support early understanding of rework/failures, ABS is equipped with a flexible rework policy; in terms of rework duration, rework likelihood, and assigning an actor to a reworked task. A rework task can be implemented by using the same actor, or a different actor. In either case, the rework duration can be adjusted into three different manners: slow rework, accelerated rework, and full rework duration. Furthermore, occurrence of rework can be based on a specific probability, which is set by the user.

5 MODEL EXECUTION AND DUSCUSSION

To address the model specifications, we need a tool, an intermediate between highly flexible simulation languages, and those high-level simulators, scalable and easy to use in practice. Arena® (Rockwell Automation) laid itself aligned to our objectives, as a simulation basis, by providing the alternative and changeable templates of graphical simulation modeling and analysis modules. In this section, an overview of the simulation results is presented, for a simplified version of a packaging design process, which is characterized by: 20 tasks, 10 technical parameters, 8 actors, and 7 behavioral parameters. In order to verify the process behavior, further analysis on the process sensitivity is exemplified, in relation to the dynamics of actors' behavior.

5.1 Simulation results

Thanks to integration with Arena®, ABS can promise a broad range of output information, including both typical planning issues (i.e., sequence of activities), and also further planning issues such as identification of criticalities (e.g., association tasks-actors, influencing actors, interactions structure). Different sources of uncertainty, discussed in Section 3.1, are captured into the simulation model by using proper probability distribution, e.g., Uniform Distribution to capture uncertainty in actors' behavioral confidence level, or Triangular Distribution to capture uncertainty in task duration, and cost. Some highlighted results are presented in Figure 5, after 500 simulation runs. There can be three classes of simulation outcomes, in general: DSM-DMM (matrix-based), Scatter plots, and Histograms.



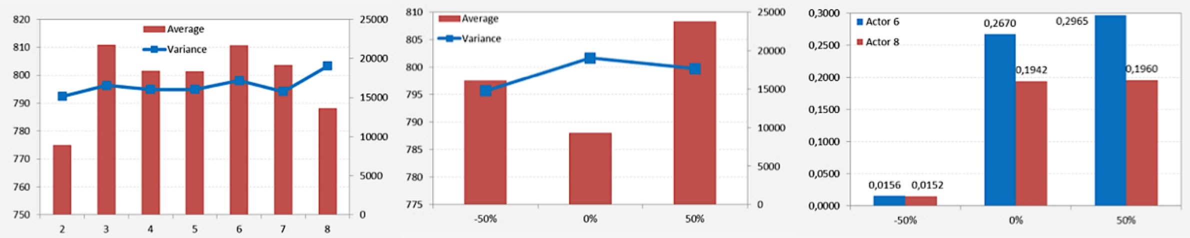
Task	Nrework	TPT	TPC	Increment	Situation	PProgress	Tot. Incr.	Ac Conf	Initial Ac	Final Ac	Best PR	NHInt	NIntraInt	NInterInt	Ninf
1	23	3	242,32	4,68	Passed	0,05	4,68	14,96	3	3	90,00	5,45	5,98	3,40	6,98
2	98	7	525,86	6,61	Passed	0,10	11,29	13,04	2	2	120,00	7,79	7,46	3,42	6,63
4	45	11	864,07	6,18	Passed	0,20	17,47	11,53	6	6	150,00	3,55	4,37	4,59	7,38
5	41	20	1.685,22	6,76	Passed	0,25	24,23	14,19	5	5	110,00	6,53	4,87	1,56	5,06
3	31	23	2.081,12	6,15	Passed	0,15	30,38	10,10	6	6	150,00	9,88	10,31	8,01	6,87
7	25	27	2.622,73	7,97	Passed	0,35	38,35	10,15	8	8	100,00	5,84	2,14	3,79	5,16
8	40	28	2.935,43	6,17	Passed	0,40	44,52	12,15	2	2	120,00	7,06	5,35	3,49	9,77
6	11	37	3.713,21	6,36	Passed	0,30	50,87	11,43	6	6	150,00	11,29	6,97	5,23	4,61
12	5	40	3.987,52	9,28	Passed	0,60	60,15	13,21	7	7	120,00	9,34	6,39	3,63	9,20
13	15	46	4.453,20	7,52	Passed	0,65	67,68	12,31	6	6	150,00	6,33	4,70	6,22	1,98
9	40	50	4.847,23	5,55	Passed	0,45	73,22	13,61	4	8	100,00	4,68	3,59	4,61	1,95
11	14	54	5.426,78	7,53	Passed	0,55	80,75	14,01	2	2	120,00	4,78	9,02	4,32	11,02
10	45	57	5.805,39	7,66	Passed	0,50	88,41	11,28	7	7	120,00	9,52	7,21	1,62	4,41
16	10	61	6.490,45	8,11	Passed	0,80	96,52	11,60	6	8	100,00	9,81	5,09	8,57	1,87
14	144	65	6.881,10	9,47	Passed	0,70	105,99	11,24	8	8	100,00	5,16	3,49	5,81	2,26
15	5	74	7.624,77	5,55	Passed	0,75	111,55	13,41	2	2	120,00	8,19	7,77	3,35	11,45
17	12	79	8.175,80	5,77	Passed	0,85	117,31	10,97	6	6	150,00	7,21	2,92	4,40	3,82
18	35	84	8.465,76	7,56	Passed	0,90	124,87	13,91	2	2	120,00	4,69	2,76	6,36	8,78
19	9	88	8.869,95	10,52	Passed	0,95	135,39	10,76	1	1	100,00	4,69	2,76	6,36	8,78
20	42	97	9.335,01	6,78	Passed	1,00	142,16	11,30	5	5	110,00	3,65	3,60	10,93	8,23

Figure 5. Highlighted results on simulation of ABS model

Matrix-based information are adjusted to give the optimal set of actors-tasks, identification of criticalities (e.g., after 500 runs, the critical path (in-average) is: 2-3-6-11-15-18-20), duration-cost trade-off, project progress, increment achieved in quality parameters, and details of actors' behaviour. *Scatter plots* and *Histograms* aim to graphically support the relation between major process characteristics, i.e., duration, rework, cost, the most probable project duration-cost, frequency/ cumulative distribution of durations-costs, and in a more detail manner, some considerations according to the impact of actors' behaviour on the process targets.

5.2 Discussion and managerial implications

In addition to the diverse range of output information, ABS simulation model can support process improvement through an "advance process analysis" tool. The objective is to provide managers a tool for detail modelling of uncertainties associated with both technical and organizational aspects of DP, and for analyzing their impact on the process characteristics, when simultaneously affect the process. Doing this way, the current version of ABS supports sensitivity analysis in: process size, rework (duration and likelihood), (technical and organizational) parameter confidence levels, number of people involved in process, degree of interactions among actors, and influencing actors. Two examples are presented in Figure 6, in relation to the impact of variation in number of actors on process duration (Figure 6-a), and the impact of changes in behavioral confidence levels on DP duration (Figure 6-a,b).



(a) Impact of variation in number of actors on duration

(b) Impact of variation in actors' behavioral confidence on duration

(c) Overall utilization of actors in process against variation

Figure 6. Example of process analysis, because of variation in: (a) number of actors, and (b-c) actors' behavioral confidence

In the former, the same process is executed by different number of actors, whom with different roles. As a presumption, the priority for elimination of actors from the model was based on the role of actors (lower responsibility, earlier elimination). As the result, when allocating people to the DP, there should always make a balance between overall project duration and cost. Another issue of our analysis is related to the behavior of actors, for which we picked two key actors with more responsibilities, and changed their behavioral parameters within the range of [-50%,50%]. One resulting point is that enhancing actors' qualifications, and consequently getting more responsibilities, is led to increase in process duration. The finding would be rationally true, since the waiting time for availability of resources will be increased, and therefore it takes a longer time for consequent tasks to be executed.
From a managerial viewpoint, the following implications might be helpful to better understanding the utility of the proposed tool. From a micro-level consideration, ABS can:

- Present an appropriate estimation of project duration and cost. Given the target deadline or cost, the model also can provide the optimal composition of tasks-actors, and associated parameters, to reach the target.
- Can offer the most appropriate rework policy, and consequently a cheap set of rework to the managers. It would be done based on advance analysis of process sensitivity with respect to the different rework durations, and probabilities.
- Can determine: the right number of actors, and also the manner they should behave and interact, in order to achieve the most reasonable number of reworks, in an acceptable length.

From a macro-level consideration, ABS can support:

- Future development of process models, through presenting a baseline on the integrated modeling of socio-technical DPs.
- Predictive planning processes, through systematically modeling of multiple types of uncertainties, and their reciprocal impact on the process behavior.

- Management of information flows, through presenting an information mechanism, to enable actors to adjust their behavior in a more effective way.

6 CONCLUSIVE REMARKS

ABS is a process modeling tool, aiming to support managers not only on the content of the process, but also on the way that it must be carried out, to be effective during execution. It is flexible and scalable in structure, so that can be extended either horizontally (to apply at all engineering system levels), or vertically (to model the DP at different levels of granularity). In the current practice, ABS is under development for specific project cases, with the specific focus being cast on how multiple types of uncertainties can affect each other and process characteristics, to support project management. In order to use ABS, it is necessary to well-define the set of parameters that can affect the process behavior, especially those related to the human-behavior. For future directions, application of other evaluation and optimization mechanisms (e.g., DSMs, meta-heuristics) on ABS would be suggested, or such further applications of ABS into different industry types.

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