# Supporting the design for emergence of group decision process

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**Abstract.** In the general context of **Group Decision Support System** (GDSS), the paper investigates the possibility to externalize and support from a metacognitive perspective the effective use of facilitation knowledge with self-development capabilities. The experimental results make evident that these capabilities may be easily engineered by adopting the basic principles of the *design for emergence* in constructing an e-meeting facilitation tool that act as a stigmergic collaborative environment for the participants. Basically, the GDSS needs to provide a minimal structure for modeling the **group decision process** (GDP) which enables a participant-driven approach to group facilitation and magnify the sense of social participation. In this way the GDSS may provide a collaborative environment where unpredictable and more effective models of GDP design will emerge through the exploration of the problem space.

**Keywords.** Group decision support systems, group facilitation, design for emergence

## Introduction

GDSS is probably the most emblematic type of Decision Support System where the division between the social aspects aimed to be supported and one that is actually supported is ever more obvious. This gap is usually narrowed by a meeting facilitator, a third-party person responsible to find the best matches between the possible configurations of the available technology and the group engaged in solving a complex problem. These matches are reflected in the GDP design or, more conventionally, in the meeting agenda for tackling a group decision.

To overcome the problem of cognitive complexity for the GDP design, the **thinkLet** (TL) concept has been introduced to define the smallest piece of essential facilitation knowledge of group decisions [1]. A TL basically describes an interaction protocol among the GDSS's participants, a protocol that is structured and mediated by one or more collaborative tools from the GDSS software suite. Thus, the conceptual model of a GDP takes the form of a collaborative actions shared plan, each collaborative action being an interaction protocol embodied in a TL. As any plan, the

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model for a GDP is hierarchically decomposed at different levels of abstractions in sub-plans that are explicitly codifying the facilitation knowledge about the collaborative patterns of interaction [2] and workflows [3]. This conceptual structure of a GDP model is acknowledged in any application domain of the GDSS technology, such as project management [4], user requirements elicitation [5], crisis response management [6], scenarios design [7], risk identification [8] etc. Even if this approach proved to be useful in certain circumstances, it suffers from the same hurdles of knowledge engineering in Artificial Intelligence: 1) the lack of an adequate representation for the facilitation knowledge to naturally support and reflect their self-development nature as regards the socio-technical aspects of GDSS assimilation in operational context; 2) the purely theoretical perspective over the GDP model that is disconnected from the environment which enclose the relevant knowledge (i.e., problems, users and technology). These weaknesses have been stressed since the late eighties, when the need for active and situated DSS [9] has been soundly emphasized. Additionally, the approach stresses a *synchronic perspective* over the GDSS capability to amplify the synergy of group knowledge as reflected in many field studies of GDSS research. These studies report on the ability of GDSS technology to augment the core attributes of collective intelligence (i.e., memory, creativity, learning, problem-solving capabilities) and reduce the limits encountered in traditional group meetings [10]. There are studies (i.e. [11]) that report on inferior performances, suggesting an inefficient knowledge transfer at the metacognitive level.

In contrast with the mentioned approach that relays on codifying problem-specific facilitation knowledge to support the GDP design by matching the possible technology configurations with the social aspects of the group, the paper argues and investigate the possibility to externalize and support, from a *diachronic perspective*, the effective use of facilitation knowledge with self-development capabilities. The diachronic perspective over the GDSS capability to amplify the synergy of collective knowledge, was recently introduced through concepts such as Social Decision Support Systems [12] or Societal-Scale Decision Support Systems [13]. In this case the collective knowledge is recorded and preserved from a group to another across successive meetings. Additionally, it presumes a participant-driven approach to facilitate the e-meetings and consequently the collaborative modeling of the GDP. Conceptually, this approach corresponds to the dynamic facilitation method [14] proposed as a substitute for the classical methods. Unlike the conventional methods of facilitation, the dynamic method does not predefine the entire structure of the GDP model but is trying to support the creative process in elaborating alternatives for the GDP design. This aspect emphasizes not a one-shot solution for the GDP model, as reflected in the conventional facilitation methods, but a going-concern approach to its design where the iterative planning process is socially constructed in a participative and continuous way [15].

Nevertheless, to support the participant-driven facilitation of e-meetings from a diachronic perspective introduces additional problems such as participants' fluctuation and different operational contexts which amplify the cognitive complexity associated with the effective use of a large knowledge base. From the engineering stance, the only feasible solution to tackle these challenges is to adopt the basic principles of the *design for emergence* in constructing the e-meeting facilitation tool. The design for emergence presumes the creative use of technology driven by social contexts and collaborative processes based on the ability to communicate the relevant knowledge in a symbolic way [16]. That entails the implementation of a simple collaborative working environment, with a minimal structure for modeling the GDP, where unpredictable and more effective ones will emerge through exploration of the problem space.

The paper presents a stigmergic approach to engineer the facilitation tool for the collaborative GDP design. The remaining part of this paper is organized as it follows. The next section presents a brief analysis of the innate relationship between metacognition and stigmergy relative to the GDP design. Section 2 describes the main components of the stigmergic framework for the GDP design: the structure of the semantic environment and the low-level users' behavior in interacting with this environment. This framework is tested in a socio-simulation experiment and implemented in a prototype depicted in Section 4. The paper concludes with some remarks regarding the engineering issues to support the design for emergence of GDP.

## 1. The sociality of cognitive stigmergy

### *1.1. A metacognitive perspective over the GDP design*

Metacognition generally refers to the individual knowledge representations that are related to a cognitive process such as the design of a GDP for a problem type. In its classical formulation [17], the theory considers that any cognitive process is manifesting on two distinct levels: *the level of real-life cognitive activities* (the so called "object-level"), such as problem-solving, and the *level of symbolic representation and control* of the former one (the so called "meta-level"), such as GDP control. Between the two levels there is a monitoring process that keeps the "meta-level" in sync with the current state of the "object-level", and a control process that runs the "object-level" behavior in an iterative and reflective way. For group decisions these processes are executed by the human facilitators who regulate the GDP execution.

With the key role of controlling the interaction of a person with the real world the metacognition is essentially distributed over mind and environment [18]. To amplify metacognition, humans are using external representations in the environment for their "meta-level" (cognitive map). These representations are realized with the aid of cognitive artifacts that are organized in a composite symbolic structure as a mental support for possible actions at the "object-level" [19]. These representations are realized either in a physical (i.e., the desk calendar) or artificial (i.e., the calendar tool in any operating system) environment.

The essential role of the environment (physical or artificial) becomes even more evident in collaborative activities where it plays the extra role of coordinating the individual cognitive activities. With a long tradition in GDSS research, this role has been extensively investigated in the social sciences theories such as activity theory [20] or situated and distributed cognition [21]. For example, the tool used to record the meeting agenda plays an important cognitive role for coordinating the execution of the GDP: it represents the dependences between different sessions of the GDP, the temporal limits for each session, and records the instructions on how to use each software tool. Unfortunately, the meeting agenda supports only the coordination of problem-solving activities at the cognitive level and completely neglects those related to the metacognitive processes of the GDP's designing. While this approach was well suited for the the design and execution of the GDP by a skilful facilitator, it is completely inadequate to support the co-development of a shared mental model over the GDP in a participant-driven approach of e-meetings facilitation.

A common way to support the collective metacognitive processes is to externalize the problem space in a semantically-rich structure or a collective mental map [22]. The basic assumptions for this concept are inspired from the ants' behavior which exploits the external environment to manifest a collective intelligent behavior. In contrast to the blurry theories of social sciences, the underlying coordination mechanisms used by ants to coordinate their behavior may be easily implemented in a software tool. As a consequence, the participant-driven facilitation of e-meeting may be supported from a metacognitive stance by a collaborative software tool able to represent in a collective mental map the problem space of GDP design.

### *1.2. Metacognition and stigmergy*

How ants are building their collective mental maps is probably one of the most cited examples of a collective intelligent behavior. Their individual simple behavior results in an emergent intelligent behavior of the colony that is able to find, without any central coordination, the shortest path from the nest to the food source. The coordination is realized by employing some simple coordination mechanisms (i.e., aggregation of preferences, positive and negative feedback), called *stigmergic coordination mechanisms* [23], which restricts the sensorial (cognitive) aptitude of an ant to the local pheromone trails with no mental plan on how to find the shortest path or knowledge about the environment in which they act. Instead, they construct an external navigation map through the pheromone trails.

Even if the term stigmergy has been primarily used for typically reactive (non-rational) agents, its relationship with cognition was investigated for the first time by Susi and Ziemke [24] and illustrated in several examples of social activities [25]. For instance Elliot [26] found that stigmergy is the coordination mechanism inherent not only in collaborative processes over physical environments, but also in a wide variety of collaborative support systems such as wiki and community blogging, Google's PageRank system, eBay's online auctioning, Amazon's recommender systems, Wikipedia.org, and Second Life. In these examples, humans are exploiting the fundamental advantage of the stigmergic coordination mechanisms that prevent their human cognition to be exposed to the complexity of an open, dynamic and unknown environment [27]. As users interact only locally, there is no need for prediction since the environment records actions in the problem space and the unexpected events are automatically traced through the outcome of the users' actions over the environment.

Given that the essential capability of any stigmergic system is to transfer the cognitive complexity from the humans to the environment [28], the problem-solving capabilities of the users decisively depend on how the problem is represented in the digital environment. A standard representation of the problem in the environment is realized as a composition of cognitive artifacts linked in a weighted graph. Basically, this graph signifies a navigation map that supports the cognitive effort to find and reach any artifact from the place where it is needed. The artifacts commonly stand for the possible states of the problem, while the links are the set of possible actions that guide the decision process (the conceptual navigation) from one state to another of the problem space. Similar with the intensity of the pheromone trails in the case of real ants, these actions are weighted in order to discriminate the most effective ones.

## 2. A stigmergic framework for GDP design

This section introduces the basic architectural issues to engineer a collaborative software tool able to: 1) represent, as a collective mental map, the problem space of GDP design; and 2) support the conceptual navigation in the problem space by minimizing its associated cognitive complexity. Generally, any stigmergic architecture entails the description of the agents' behavior and the structure of the shared environment where the agents are localized and moved over it [25]. For the GDP design, the agents are the users responsible to design, execute, and evaluate a GDP model (i.e., to find a path through the conceptual space of the available TLs.), while the environment is the collaborative facilitation tool that supports the conceptual representation of the problem space comprising all the TLs discovered and documented by the users' community. Note that the primitive decomposition unit for a GDP may be any conceptual artifact used to structure its design, such as "session topic' of the OpenSpace-Online [29] instead of TL. Here, the TL concept is preferred as being widely acknowledged in the GDSS research community.

### *2.1. Users' behavior in the conceptual space of GDP design*

As mentioned before, the *agents* are the users who interact with the envisioned collaborative tool to design the GDP. Conceptually, at a certain point in time during the GDP design, a user is "located" in a node (TL) of the problem space, performing one of the following basic actions:

- *evaluating the preferences* for the next possible TL that may be executed, given the current execution context of the GDP;
- *selecting* the next best TL for further completing the GDP model;
- *executing* the TL from the model; and finally
- *assessing the performance* for the executed TL.

Note that these actions are not necessarily restricted to a single TL and may be extended to any sequence of TLs.

The evaluation activity presumes to quantify the performance for any TL that may be used to further complete the GDP design. When the performances for any possible action are known, there will be a probabilistic distribution of preferences to select one of them as reflected in the Luce's selection axiom [30]:

$$p_{jk} = e^{CP_{jk}(TL_k)/T} \Big/ \sum_{i=1}^{m} e^{CP_{ji}(TL_i)/T} \qquad (1)$$

where $p_{jk}$ represents the preference for an alternative TL, i.e. the selection probability of the TL $k$ from the TL $j$; $i$ is the index of TLs connected from the side of node $j$ (in fact all the $m$ TLs available in the problem space as long the graph is fully connected); and $T$ is a parameter used to define the deviation from a pure rational behavior.

The above formula is the most common model of stochastic decisions due to its correlation with the psycho-social observations of human behavior in several domains [30]. As a result of normalization, the preferences for the unexploited TLs are diminishing after each performance update. This mechanism replicates the pheromone evaporation process of the real ants (e.g., even if a TL has been positively evaluated after an execution of a GDP model, the associated preference will decrease once a better alternative is discovered and more frequently used). The uncertainty associated with the construction of preferences is generally modeled in equation (1) with the parameter $T$ that ranges between 0 (when selection is deterministic as is the ideal case of a perfectly informed decision) and 1 (when the selection is completely random as in the case of a completely irrational choice). Note that Luce's selection axiom does not specify the reasons of uncertainty which for the GDP design may cover any aspect of complexity, unfeasibility, cost or even refusal to evaluate the performance of a TL after its execution. Nevertheless, we use the Luce's selection axiom only in the socio-simulation experiments (see the next section) that are conducted to inform the engineering of the real tool used to support the GDP design. It is not used to any further extent in the real implementation where the users will obviously interact with the tool in their own way.

The evaluation of a GDP model entails its subjective assessment against some performance criteria. Note that in the research field of GDSS the cognitive and metacognitive levels are well reflected in a clear distinction between the GDP objectives and consequently between the performance criteria:

- at the *cognitive-level* the process is driven by short-term goals from a synchronic perspective (i.e., effectiveness, efficiency and satisfaction with the GDP); while,
- at the *metacognitive-level* the process is driven by long-term targets that go, from a diachronic perspective, beyond the problem-solving task (i.e., GDSS adoption, collaborative learning, ability to team up in the future, etc.).

These two goals may be incompatible and are matched through the control process which may be either *static* (through the selection of the best GDP model that fits the currents socio-technological context) or *dynamic* (through instantaneous changes in the structure of the meeting agenda). Here we refer to the evaluation of a GDP model in respect to the cognitive-level objectives, the later ones being discussed in the last section.

### *2.2. The structure of the problem space*

According to Parunak [25], a stigmergic environment assumes the definition of three main components: topology, states, and processes.

Structurally, the *topology* may be viewed as a fully connected weighted graph that codifies the facilitation knowledge to support the group decision in e-meetings. This knowledge presumes correlated information among the users and the TLs, reflecting the users' evaluation of the performance for a TL (a node in the graph) relative to a problem type. The performance of a TL is stored, for each problem type, in a variable associated with each edge of the graph. The problem type is simply codified through a unique *ID* to distinguish among different performances when they are read, during the design phase of the GDP, or modified, after the GDP has been executed and evaluated by the users.

The performance from all the graph's edges describes the state of the environment over time which executes a set of processes on the performance variables (i.e., aggregation end evaporation in the case of ants). In our case, we apply a simple weighted additive rule for the aggregation of performances:

$$CP_{jk}(TL_k,t) = CP_{jk}(TL_k,t\text{-}1) + IP_{jk}(TL_k)/w \qquad (2)$$

where $t$ represents the temporal component of the model which is incremented by one for each successive use of the GDSS; $k$ is the TL's identification index from the set of TLs used to model the GDP; $IP_{jk}(TL_k)$ – is the user's individual evaluation of the performance for the $k$-th TL assessed from the side of TL $j$ at moment $t$; $CP_{jk}(TL_k,t)$ and $CP_{jk}(TL_k,t-1)$ are the new and previous values of the collective performance stored on the edge between the TLs $j$ and $k$; and $w$ is a tuning parameter to weight the impact of the last evaluation in relation to the previous ones.

The collective performance, as considered in equation (2), is constructed around some objective evaluation criteria, such as effectiveness and efficiency. According to the social sciences theories (i.e. adaptive structuration theory, activity theory), TL's performance is influenced by: technology (i.e., the feasibility constraints imposed over the TLs' execution order), group (i.e., the match between the group size and a specific TL), and problem (i.e., by the difference between the current state and the desired one). Since we are interested in the subjective evaluation of the TLs' performances for a certain problem type, the collective preference must quantify the group's perception as well. Thus, the TL's *subjective performance* (SP) may be formalized as a linear function dependent by: 1) the *collective performance* (CP) of a TL evaluated by the entire community of users (as defined in (2)); 2) the *usage degree* ($UD_{Group}$) of a TL by the group involved in the GDP, and 3) the *collaboration degree* ($CD_{Group}$) among the group's members relative to a TL. Thus, the subjective performance of the $k$-th TL, evaluated from the side of TL $j$, is:

$$SP_{jk}(TL_k) = \lambda_1\, CP_{jk}(TL_k) + \lambda_2 UD_{Group}(TL_k) + \lambda_3 CD_{Group}(TL_k) \qquad (3)$$

where: $CP_{jk}(TL_k)$ is the normalized collective performances computed in equation (2); $UD_{Group}(TL_k)$ is the average usage of $TL_k$ by each member of the group, divided at the total number of $TL_k$ uses from the time when it has been registered in the system; $CD_{Group}(TL_k)$ is the average collaboration among the group members for the execution of $TL_k$; $\lambda_1$, $\lambda_2$, $\lambda_3$ are tuning parameters to reflect the impact of participants' experience with the GDSS ($\lambda_2$) and prior collaborations ($\lambda_3$) in relation to the collective performances ($\lambda_1$) over the GDP performance. Consequently, in this later case, the environment should maintain information related to the number of usages and collaborations among participants for each TL. Therefore in (1) the collective preference $CP_{jk}(TL_k)$ may be easily replaced with $SP_{jk}(TL_k)$ to account for a shared understanding over de GDP model when selecting the most suitable TL. Note that equation (3) is not trying to formalize all the factors that have an influence, from a metacognitive stance, over the execution performances of a GDP. Instead, it shows from the engineering perspective the easiness to add new variables (to change the structure of the shared environment) without the need to make any adjustment in the coordination mechanisms (in (1)).

### *2.3. The design for emergence of the e-meeting facilitation tool*

Any stigmergic system has two main components: the population of agents and the shared environment through which they are interacting and coordinating their behavior (Figure 1). Considering the general framework proposed by Parunak [25] for describing a stigmergic system, the envisioned collaborative tool aimed to support the collective intelligence of GDP design has the following general features:

- The *environment* - is the tool that records the design strategies for a GDP, with the following characteristics:
  - The topology – is given by the collective mental map for the GDP design in the form of a weighted graph which contains correlated information among the users and TLs; the edges between TLs indicating users' preferences in respect to a certain problem type.
  - The states – are given by the collective performance of a TL (CP), usage degree (UD), and collaboration degree (CD) among users for a certain problem type, a tuple $<CP, UD, CD>_{\text{problem type}}$.
  - Dynamics – is given by the maintaining process for the TL's CP, UD and CD; to these ones we can add the addition of a new TLs or the removal of an existing one.
- The *agents* **-** are the decision-makers engaged in modeling the GDP, which: a) evaluates the preferences for the next possible TL (or a group of TLs) given the current problem execution context; b) selects the TL (or a group of TLs) considered to be optimal; c) executes a TL (or a group of TLs); d) assesses the performance of the executed TL (or a group of TLs).
- The *emergent behavior* of designing the GDP resides in identifying relevant TLs which maximize the GDP performance for a problem type.

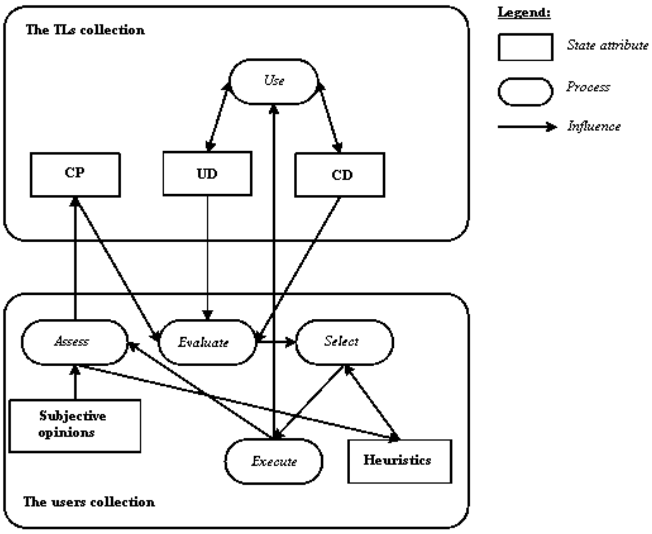


**Figure 1.** The interaction between the GDSS's users and the collaborative tool aimed to support GDP design.

## 3. Experimental and implementation issues

In the view of envisioning a software tool as a collaborative environment for the GDP design, we developed a socio-simulation experiment to mimic the use of this tool in real situations. The simulation investigates the conceptual navigation of users over the semantic structure of the problem space for facilitating the e-meetings. In the next subsection only a sample of the experimental results is presented, a detailed description and analysis being beyond the scope of this paper (for instance, some complementary results are presented in [31]). Contrary to the classical field studies that are found in the GDSS research, the social simulation tries to: 1) investigate “in silico” some hypothetical conditions for collaborative GDP design; 2) validate the conceptual framework described in the previous section; 3) demonstrate the feasibility and simplify the implementation of the stigmergic framework in a GDSS; 4) use the simulation as a tool for virtual experimentation of the GDSS use.

### *3.1. Some experimental results*

The model described in the previous section has been implemented in the Netlogo multi-agent simulation environment [32] and tested following the research methodology proposed by Carley [33]. In this experiment the users (“turtles”) are engaged in facilitating the e-meetings by trying to define the GDP model for a problem type which their cognitive movement in the conceptual graph of the problem space. The number of TLs that compose the graph may be arbitrary set from the interface while their individual utilities for a certain problem type are predefined with random values when the experiments are initialized.

In Figure 2 the aggregate performances from 30 experiments of a GDP design for different experimental variables are shown: the *problem complexity* (PC) - defined as the number of TLs that are composing the GDP; the *social temperature* (T) - as defined in eq(1); and the *number of TLs* (NT) that are available in the conceptual problem space. An experiment consists of 100 successive iterations (trials to define a GDP), each iteration standing for a complete execution cycle of a GDP. It presumes to: 1) find a suitable model through the successive selection (using the equation (1)) of TLs that compose the GDP for a given problem type; 2) execute the identified model and assess its performance by reading and averaging the predefined utility values of all the TLs that compose the GDP model; 3) evaluate the model by updating the performances values (using the eq(3) with $\lambda_1$=0.55, $\lambda_2$ =0.3, $\lambda_3$ = 0.15).

As may be seen in Figure 2 the *problem complexity* has a significant impact over the convergence rate to an optimal solution (close to the performance value of 1) which requires an increasing need for experimentation and creative use of the GDSS for the problems with higher complexity. Considering that the problem complexity is in many cases a subjective factor that reflects the GDSS capabilities to provide relevant information when designing the GDP, the key role of the stigmergic coordination mechanisms becomes very clear in reducing the cognitive complexity as a result of restricting the decision of TL’s selection to be based on the locally available information (see equation (1)).

The *social temperature* variable captures the user’s receptivity to the suggestions offered by the system in designing the GDP. Intuitively, for higher values (close to 1) it favors the creative use of the system (exploration of the problem space) while for lower values it allows the reuse of the models discovered in time by the GDSS’s users (exploitation of the problem space). As may be seen in Figure 2 a creative use of the GDSS gives better performances and, consequently, the GDSS should encourage the creative use of the system when the problem space is unstructured. Again, the stigmergic coordination mechanisms give the possibility to locally measure the information entropy, the structuration degree of the problem space, and reduce the global uncertainty in planning the GDP to a single TL choice.

Regarding the *number of TLs* that compose the problem space it is worth to observe that, despite the different values assigned for this variable, the convergence rate is the same (0.11 in Figure 2). This result shows very clear that the stigmergic coordination mechanisms are decoupled from the uncertainty associated with the environment where the global behavior (the resulted model for a GDP) emerges from the local decisions (TL selection).

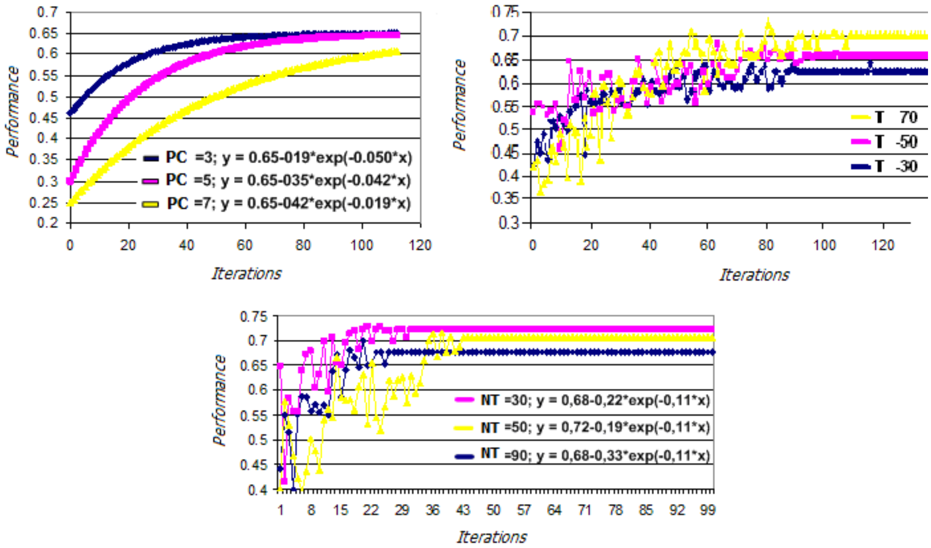


**Figure 2.** The influence of the PC, T and NT variables over the GDP models' performances.

### *3.2. Implementation issues*

The experimental results presented before demonstrate the clear capabilities of the stigmergic coordination mechanisms to provide, in time, better performances for the GDP design. From the engineering perspective the required functionalities to design a GDP such as selecting and elaborating a GDP model are emergent functionalities. The selection of a GDP model presumes user's activities related to the identification of a suitable GDP model for a certain problem type (the feasible paths through the conceptual collective map of the problem space), while the elaboration of a model for a GDP entails a detailed design of a completely new GDP model.

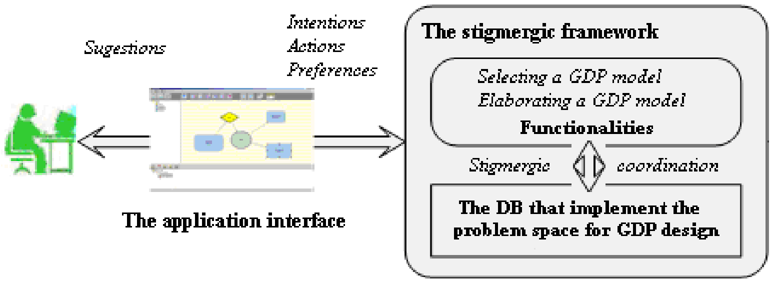


**Figure 3.** The users' interaction with the stigmergic framework for GDP design.

In Figure 3 is represented the user's interaction with the implemented stigmergic framework for the GDP design. The dialog between the user and the stigmergic framework is inspired from the shared plans theory [34] and is detailed in [35]. Briefly, the user is communicating through the interface his/her intentional context regarding the GDP design. The intentional context is identified in respect to: 1) the design intentions of the user – communicated through the conceptual formalization of the GDP model [31]; 2) the selected action – communicated through the commands expressed in the interface (i.e. identification of a GDP model, selecting the next TL etc); and 3) the user's preferences – communicated through the value assigned to the T parameter (see equation (1)) that reflects the long term user's intentions to use the GDSS.

From the metacognitive perspective the application supports some additional functionalities such as the adequate: 1) *placement* of the decision-maker in the conceptual map of GDP design (from where to start considering his/her knowledge and experience); 2) *restrictions* for navigating in the conceptual design space in respect to user's experience (the identification of the conceptual artifacts that compose an as optimal as possible GDP relative to user's interest, group knowledge and experience). According to the Adaptive Structuration Theory [36] this is related to the concept of user's trust in the "spirit" of the available functionalities offered by a GDSS as a result of supporting a common interpretation over these functionalities from a metacognitive stance. In other words, the users must believe that the resulted model for a GDP (in the way in which it is supported by the GDSS) will result in the desired outcome through a consensual perception over the functionalities that are used.

## 4. Summary and conclusions

Although has been extensively acknowledged the great impact of the GDP metacognitive awareness on the decision outcome [37], the research on GDSS has paid little attention on supporting it, primary due to the conceptual complexity associated with the encapsulation of social and cognitive aspects of group decisions and not to the technical limitations.

The paper argues and investigates the possibility to externalize and support, from a diachronic perspective, the effective use of facilitation knowledge with self-development capabilities. These capabilities may be easily engineered by adopting the basic principles of the design for emergence in constructing the e-meeting facilitation tool. That entails the implementation of a simple collaborative stigmergic environment with a minimal structure for modeling the GDP, an environment that enables a participant-driven approach to GDSS facilitation and magnifies the sense of social participation where unpredictable more effective models will emerge through exploration of the problem space for GDP design.

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