CHAPTER-5

QUANTIFIED HYBRID SOFTWARE DEVELOPMENT MODEL

5.1. Hybrid Model

The proposed study has developed a quantified hybrid model that will be used by the managers and stakeholders of the IT organization to evaluate the extent of successful decision making for selecting a particular software development methodology. As priorly discussed in Chapter 4, the IT organization includes various variables that affect the quality of software production both intrinsically as well as extrinsically; hence, the proposed quantified hybrid model adopts the strategic decision making theory as well as the probability theory to mathematically model it. The design principle is majorly based on game theory which can potentially map both the strategic decision making as well as probability theories. The reasons for adopting the game theory are as follows:

Existing techniques for solving highly complex problems with the maximum number of unknown variables can be used by implementing Fuzzy Logic, Neural Network, Genetic Algorithm (Doumpos & Grigoroudis, 2013). But, all such models are highly dependent on training as well as database, which means that bigger the size of available training data, more accurate will be the outcome. In the area of software project development, there are various unseen circumstances like skill gap, requirement volatility, attrition rate, poor selection of quality standards etc., which are computationally complex processes to be modeled upon. Such modeling requires a strong set of assumptions as well as real-time constraints for performing reliable decision
making. The game theory is based on the probability theory as well as consideration of real-time constraints that permits the decision maker to evaluate the outcomes of their adopted decision by scrutinizing their payoffs. The game theory is completely independent of any training data, as with the evolution of games (or interactions), the data becomes highly intellectual to furnish more information without any training process involved in it. Hence, owing to less computational complexity while processing unlike Fuzzy Logic, Neural Network, Genetic Algorithm, the game theory is one of the best modeling in the highly complex scenario of software development methodologies.

Consideration of the game theory includes the scenario where the actors (managers) are supposed to adopt their decisions that can strongly influence their performance as well as their team performance too. Interestingly, as the game theory is designed and based on the probability theory, it lays strong emphasis on hypothetical frameworks that allows for easier analysis for the interactions of the managers involved in the business process. Hence, the game theory can be used to check the level of effectiveness of the decisions taken by the managers in IT firms. It also provides the highly contentful and conclusive information for the most complex data structure in the software development methodologies, by allowing the design of a mathematical model with the most critical real-time variables with high constraint factors.

Hence, it can be seen that adoption of the game theory is the most appropriate selection for designing the proposed quantified hybrid model that considers various real-time constraints, performs mathematical modeling, and consistently evaluates various factors of uncertainties and impending attributes which influence the successful implementation of SLA compliance of any software development model with measurable outcomes.
5.1.1. **Rationale of the Model**

Tom Devane, one of the most acclaimed authors of Six Sigma, in his book “Integrating Lean Six Sigma and High-Performance Organization” has written some of the critical differences from operational viewpoint of development methodologies between conventional and high-performance organizations (Devane, 2004). The discussion laid a foundation of the fact that there are multi-dimensional complexities in different activities carried out in high-performance organization, where the key players are identified as senior managers, middle managers, front-line managers, and workshop managers (Devane, 2004). In reality, the software development methodologies practiced in the present time are mainly Agile and conventional models like Waterfall, Spiral, Iterative, etc. which are always accompanied by certain loopholes that are detrimental for technical adoption by high-performance organizations. Devane was always in support of adopting Lean Six Sigma principles as it has already exhibited its success in various giant organizations like Motorola and General Electric. Reputed authors Snee and Hoerl (2003) have also emphasized the adoption of Six Sigma, where it was discussed that Six Sigma could look fair in reading theoretically, but complicated to bring the theory in real-time implementation. Hence, the author suggested that if Six Sigma is difficult to be adopted for first timers who are more inclined towards conventional practices, then there is a better alternative for that. Six Sigma could be possibly integrated with slight adjustment in the existing process management to ensure that there are better opportunities in both administrative as well as transactional processes (Snee & Hurl, 2003). However, such standard theories essentially prove that there is a high scope of improvement using the leading Lean Six Sigma with the existing Agile manifestos for enhancing the quality of the product development. Hence, this section will discuss about a mathematical modeling that is designed with utmost care both analytically and practically to validate the outcomes of its applicability in real-time scenario of software development.
5.1.2. **Need of the Model**  
Following are the justified reasons for highlighting the genuine need for mathematical modeling; which is also the objective of this research work.  

**Lack of Mathematical Approaches**  
Various real-time constraints like Human Resources, Customer Requirements, Supplier Availability, Cost Overrun, Schedule Slippage, Usage and Adoption of Novel Technologies, and Requirement Volatility are some of the critical parameters behind the success of every software development model adopted. However, all such parameters are almost impossible to ascertain as they cannot be framed as discrete variables, for which reason, there is no such software or framework existing till date that can perform the analysis of the effectiveness of the model for future requirements. In the existing system, all the predictions\(^1\) of success or failure of the software development model are based on the availability of resources and without any type of consideration of the real-time constraints. Hence, such models are definitely less reliable in the long run and call for various amendments during the different stages of project development. Hence, a new model is required that can overcome all such issues.

**Presence of Uncertainty in Process**  
The area of software development methodologies is shrouded with various uncertainty issues, which cannot be modeled or computed directly. The computation performed with available resources may give a reliable solution for the present requirement, but does not ensure when the requirements or the real-time constraints keep on changing, which is very frequent in the IT industries. Hence, such uncertain environments cannot be designed by using deterministic techniques and only the use of a probabilistic technique can be a

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\(^1\) Predictive nature basically means that the computation should be capable of producing the possible outcomes based on data analysis, which are highly precise and accurate using probability theory and decision making principles.
solution, as the completely random variables and events in the cases can be effectively evaluating by using the stochastic principles.

Few Cost-Effective Approaches

At present, various intelligence like Artificial Intelligence, Genetic Algorithm, Bio-Inspired Algorithm, etc. do exist in the area of predictive analysis that is already in use from the last decade. One of the most challenging issues in such a technology is that they are pretty expensive in nature and their outcomes depend on the training dataset, which is heavily time consuming and depends upon programmer skills. Obviously, such a principles lack instant decision making, which is also a part of computation. Hence, a soft computing technique is needed, which not only aids in cost reduction but also emphasizes on increased production efficiency.

Therefore, keeping in mind all the important facts discussed above, the prime objective of this part of the study is to design a mathematical model that can perform analysis using both probabilistic theory as well as strategic decision making theory for understanding the underlying connectivity of various factors responsible for success / failure of software development methodologies.

5.2. Principle of the Hybrid Model

The proposed mathematical model is designed using the strategic decision making theory (Nutt & Wilson, 2010, p.10), where the modeling principle is done on the basis of the level of effectiveness represented by the set of specific actions or behavior that a manager adopts. The design principle only considers managers based on the studies of Devane, which mainly laid emphasis on them. The prime reason behind this is to understand the effectiveness of the standards and the working principles towards process management laid by the senior and middle-level managers. It is important to highlight one potential consideration while developing this model that any
organization will not directly be able to implement new quality standards and hence the model assists in implementing a hybrid nature of quality standards by integrating Lean Principles, Six Sigma, Agile, and Scrum and comments that it is highly possible to adopt this hybrid model without involving any further costs or undergoing much re-engineering process. Hence, the prime objectives of the design principle are:

- To ensure that managers stick to the SLA of the new quality standards using the proposed mathematical model.
- To ensure that managers are guided on their imprecise decisions in the entire process management cycle by continuously monitoring their defects and further reducing them.

The system formulates the decisive structure of such managers and attempts to understand their behavior with the aid of the proposed mathematical model. The prime actors involved in this model are as follows:

**Efficient Manager (EM):** The system defines the efficient manager as an individual who is known for taking correct decisions towards software development methodologies and adhering to the standards of quality management by making continuous improvement in the process management. Some of the prime characteristic actions defined for EM are:

- **SLA Compliance (C):** This action means that managers always cooperate with the proposed protocol for software development methodologies where the core principles are designed from Lean Principles, Six Sigma, Agile, and Scrum. Each department has one manager with certain distinct roles and responsibilities.
- **SLA-Violations (D):** As the entire process management is still human-oriented (Westfechtel, 1999, p. 135) and based on experts’ opinion (Ayyub, 2001, p. 234), there are quite a few possibilities that managers may decline certain sets of SLA which they find as inappropriate with positive intentions.
- Frequency of Scrum (R): This set of action can be determined as the reporting procedure, which plays a critical role in identifying the defects in the process management before the entire department.

Inefficient Manager (IM): The system defines the inefficient manager as an individual in an organization who is characterized by low efficiency in his decision making principles towards ensuring a standardized protocol of project development methodologies. The decision adopted by him is assumed to affect the entire team performance thereby resulting in risks in almost every stage of product development. Hence, existing of IM is detrimental to cost-effective production and superior quality assurance in product development. Just like EM, each department has one IM and is mathematically characterized by the following sets of action:

- SLA Compliance (C): The basic definition of SLA compliance for IM is almost same as EM; however, there is a distinct difference being made for a better level of accuracy in the mathematical modeling. The IM chooses to perform SLA compliance in the department for negative purposes. It is said that if IMs start showing their inefficient characteristics, they have the higher chances to get monitored by the EM using the frequency of Scrum. Hence, in order to hide their inefficient decision implementation, the proposed design principle considers IMs to perform SLA compliance in the primary level. Hence, it can be seen that mathematically, the action SLA compliance, which is represented as a variable, is quite confusing as both IM and EM bear the same variable. However, the difference is that the probability of risk is quite lower for EM and quite higher for IM when they adopt the action SLA Compliance (C).

- SLA-Violations (D): The basic definition of SLA-violation is quite same for both IM and EM; however, there is again a unique difference being made between them for a better understanding. EM chooses SLA-violation for productive purpose, while IM chooses SLA-violation for
unproductive purpose; unfortunately, it can be intentional or unintentional. The prime difference is that the probability of model crash is very low for EM and very high for IM.

- Invoke Risk (A) and Spread Risk (F): These sets of action are the prime characteristics of an IM. Owing to adoption of inefficient decisions, the proposed system performs C in the initial level, which is followed by action D. Hence, adoption of action D results in an increased level of vulnerability of the model implementation that is represented by risk factor F in a department. However, owing to the chain system in process management, it is quite possible that the risk factor (A) spreads from one department to another department, thereby cumulatively affecting the production and quality assurance of all the departments.

The invocation of risk and model crash is carried out by the IM with an intention to disrupt the process management and thereby waste the organization resources. Adoption of D-strategy by EM also leads to failure of the process management just like the F strategy of IM, but unlike the EMs, which do not receive any kind of payoff when they employ D-Strategy, the IMs get payoff for invoking threat or risk factor to the proposed model.

The system presents two types of strategies namely pure strategy and mixed strategy. A pure strategy governs a complete set of specific actions to be adopted by a manager, while a mixed strategy is basically about allocation of a probabilistic factor to each of the pure strategies adopted. The design of the proposed mathematical model is inspired by staged interactions in decision making theory which is a simple set of interactions to be played by managers at individual time slots. The system considers rationality among the managers acting as both EM and IM and having the tendency to escalate their respective utilities. The concept of Bayesian Nash Equilibrium (Tolk, 2012, p. 401) is developed considering the existing belief system of managers which is further enhanced by using the concept of sequential rationality for multi-staged interactions where the strategy of the manager should yield optimal results in
the course of the interactions. Hence, the proposed system aims to explore the perfect Bayesian Nash Equilibrium (Tolk, 2012, p. 401) of this interaction as an enhancement to the existing Bayesian Nash Equilibrium.

The system also considers the existence of selfish managers, where it is assumed that certain EMs may choose to behave selfishly at some time. This may be due to the fact that the EM is facing resource (human, hardware, software, etc.) constraints at that particular instance of time. Hence, some EMs may behave selfishly only at some events but it does not mean that they have consistent harmful intentions for deteriorating the production in software development methodology. Time is considered as an important factor in the proposed framework wherein it is categorized into slots and at the preliminary interaction of each time slot, the managers should probably select their best strategies concurrently.

5.2.1. Interaction of Entities

This section basically introduces the actual structure that has been formulated for the purpose of designing the proposed framework.

5.2.1.1. Elements of the Model

The proposed system presents a modeling of regular process interactions between EM and IM as a dynamic Bayesian game and later on finding the perfect Bayesian equilibrium of the proposed study. The statistical behavior of the manager is scrutinized and the outcome of every process interactive round is recorded for the purpose of analyzing the pattern of erroneous behavior of managers present in the simulation environment. The framework considers that the private and confidential information should be maintained for all types of managers, which is usually IM or EM. The EMs form a statistical belief system towards the managers who are present in the associated departments and persistently update the value of the statistical belief system to the actions of associated managers in due course of progress in the
process interaction. On the other hand, the IMs are able to track the statistical belief system which the EMs form for them to possess.

The study considers that every action of the manager is very critical and significant and it also depends on the counter actions already undertaken by the quality control managers. The optimal outcome of the responses for both the types of managers are guided by the specific actions performed by other managers. A specific value of reputation is initialized by an EM thereby possessing the potential capability of assessing the type of managers depending upon the updated value of belief and specific value of reputation that can be termed as threshold. On the other hand, the ongoing risk of getting identified is persistently being calculated by the IM. The IM performs a decisive action termed F for spreading risk to multiple associated departments, resulting in anticipated cost of loss of production, depending on the amount of risk.

The proposed scheme does not limit the phenomenon of selfishness being exhibited by the EM in some stages of the process interaction. There is no degree of selfishness that can estimate the mischievous behavior demonstrated by the IM.

![Diagram](image)

**Figure 5.1. Considered scenario of the proposed system**

The important parameters that have been considered in the proposed framework are highlighted in Table 5.1.
5.2.1.2. Department Based Process Interaction

The proposed framework has formulation of departments as a cluster which represents a logical region of highly interconnected processes of software development methodologies. It can be seen in Figure 5.1. The formulation of the department is done in such a way, that the managers can independently depart or associate with a certain process within the cumulative simulation environment. For the purpose of authentication, the model assumes prior experience verification system, where the manager’s identity is governed by the successful delivery of projects in the past that is fixed to a certain value for computational purpose. The secondary assumption in this phase is that whenever a manager wants to join a department, the manager previously residing in that department allocates the initial belief value to the newcomer.

The system also performs a similar phenomenon for IM. Whenever an IM arrives into a department never visited before, the manager of that department will treat the IM as a newcomer and allocates the same initial belief value to him. The challenging aspect in this assumption is that when the IM attempts to re-associate with a department, the IM can actually act as a novice manager exploiting the identity which is dissimilar from the one that the previous manager used. The conceptualization of the same is supported by the fact that it is not feasible to monitor the behavior of managers outside the department. In short, it means that when an IM performs the action of spreading threat F, the reputation value is basically reset, thereby posing a threat to the quality assurance system.

Table 5.1. Important Parameters of the Proposed Framework

<table>
<thead>
<tr>
<th>List of Actions to be performed by Managers (EM/IM)</th>
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<tbody>
<tr>
<td>A_risk</td>
</tr>
<tr>
<td>A_cop</td>
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<tr>
<td>A_dec</td>
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<td>A_spread</td>
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The design of the department in an organization may be possibly done in structured or in an ad hoc manner. In a structured manner, a frequently trusted manager is selected as a team leader. The team leader will gather the information related to the reporting action, performed by the EM, only when an
associate manager is identified as an IM. However, in an ad hoc manner, all managers within a department get the circular of reporting information by the EM.

In case of positive report information, the identified IM will be penalized. However if the EM reporting action about the identification of an IM turns out to be a false alarm, the liability of the EM will be badly affected. The proposed framework does not focus on verifying the falsification of the alarm to penalize the IM. However, in order to normalize the falsification issue, the proposed system considers anticipated gain of legitimate reporting action ($G_{rep}$) and anticipated failure of non-positive alarm ($F$) for performing an evaluation of the outcomes.

5.2.2. Department Monitoring

The discussion of this section is aided by Figure 5.1, where it can be seen that an EM can select to adopt an action related to cooperation or decline and similarly an IM can select to adopt an action related to $A$ or $C$. The refusal of a manager to participate in process management system, especially the Scrum meeting, is termed as decline while if the manager makes themselves available for progressing the development process as per the SLA, it is called as cooperation. Process management is accepted as successful only when the managers at both ends cooperated or adopted $A_{cop}$. On the other hand, the phenomenon of risk action eventually leads to unwanted resource wastage as well as deterioration of the process manager in software development methodologies. An EM can adopt a decline strategy either by trying to save itself from possible risks from an IM or when the available resources do not allow it to participate in the current process management system, due to attrition, change management, skill gap or requirement volatility. Adoption of risk strategy can be used by the IM to process and thereby implement the erroneous decision leading to slippage of project schedule or cost overrun along with obvious defects. An interesting point to be observed here is that the IM gets payoff for a successful risk strategy, whereas the EM gets none.
Therefore, it is very crucial to segregate the IMs and the EMs, which is possible in the proposed mathematical model.

Using the remote technologies of ICT in an organization, a manager monitors all the exercised Scrum logs of the associate managers in the departments, but they cannot understand the cause of any process disruption or any failure of SLA implementation. This phenomenon in an organization is referred to as department monitoring. Hence, the parameters like δ, φ, and ψ are formulated for better distinction of actions of different managers.

5.2.3. Modeling Strategies

The proposed mathematical model makes use of a strategic decision making model (Kerzner, 2002, p. 175), that can be considered as a cognitive process, resulting in judging the course of action out of various possible options. As discussed in the prior section, managers can identify whether the opponent manager had cooperated (adopted $A_{\text{cop}}$) in the current stage of process by means of department monitoring. However the EM cannot identify the type of opponent by department monitoring alone since it cannot be discovered that whether the failure of process management and reducing defect density was really caused by suspected opponents $A_{\text{dec}}$ or $A_{\text{risk}}$. Thus, the EM is required to form belief about their opponent’s kind, based on the entirety of work and outcome evidence fetched. The EM thus continuously evaluates the option of belief ($\text{Op}_{\text{belief}}$) and adequacy of evidence ($\text{Op}_{\text{uncer}}$) for the opponent manager based on the feedback from department monitoring. With every successful process interaction trials the EM increases the $\eta_{\text{coop}}$ by 1, but when the process management fails the EM checks for the opponent’s strategy. If the opponent had opted for $A_{\text{dec}}$ / $A_{\text{risk}}$ then only the value of $\eta_{\text{drop}}$ would be increased, otherwise no updating of Scrum will take place in the current stage of the process interaction. A threshold policy is being followed by an EM to take reporting decision against the opponent manager. If this threshold is not reached the EM should cooperate or decline based on the current beliefs it holds for the opponent and its selfishness attribute.
IMs are modeled to be rational and thus will continuously evaluate the trust factor for itself with the EM. They also follow a decision rule to spread threats towards implemented process (F) in order to evade being reported (R). Hence, it is really difficult for EMs to trace the extent of risk factors like SLA-violation and model crash spread by IMs just on the basis of current actions or steps being taken. This fact is almost equivalent to what actually happens in real-time environment too. The proposed model uses both soft and hard thresholding factors to map the characteristics of the IM.

The model does not consider the process being controlled between two IMs as there is no utility for the IM in doing so. In other words, the IM’s capability to identify other IM is not restricted. Thus a decision process can be controlled between two actors among which one has to be an EM. Consequently two cases have evolved namely i) EM versus IM and ii) EM versus EM. Therefore, the decision process for the EM will be the same in both the cases, and thereby the sequential rationality of the staged process will be explored.

5.2.4. Multi-Stage Process

The proposed mathematical model considers multi-stage dynamic Bayesian signaling game (Dai, 2011, p. 43). Bayesian games are developed considering the probability theory and the game theory that permit accepting the curtailed information of the players (managers). While designing Bayesian games, each manager is set with certain classified information that has a significant impact on the evolution of the process, with other managers who are considered to possess information of the belief system about the classified data. These values of belief are signified by probability distribution and revised by applying Bayes’ rule in case of availability of novice information on process management. The managers select their best possible action during the progress of software development process as per the classified and belief information available.
The proposed system considers signaling concept of the decision making theory where the managers update their beliefs with the progress of the process. Usually, there are two categories of managers in the study namely i) managers and ii) team-members. The private information is basically an inherent property of managers where they can decide to transmit a specific circular about SLA according to the need of the software development method. However, the team-members watch for the circular being passed but do not accomplish any information pertaining to the type of manager. Depending on the type of information, the team member decides to adopt a specific action.

The staged process is considered straightforward as it is controlled at a particularly discrete instance of time. In this duration, both the EMs and the IMs attempt to escalate their anticipated utility thereby affirming the rationality of managers. The Nash equilibrium for a single stage process is usually termed as Bayesian Nash Equilibrium (BNE) for specified existing belief information.

However, the things are little complex when the process is multi-staged where sequential rationality plays a critical role for exploring the optimization of consequent process. Adoption of sequential rationality by the players (managers) would mean that managers choose to control the process aided by the best possible strategies as per their forecast based experience from the previous stages. Adoption of perfect Bayesian equilibrium ensures the formation of belief system for one type of managers about its counter type of managers, revising their belief information with the completion of every stage, and adopting the optimized actions with the aid of such belief systems in the current process.

5.2.5. Process Specification for Modeling

The proposed model has framed the process logic using EMs and IMs as prime actors considering multi-stage Bayesian signaling for investigating the most favorable strategy of both the types of managers. The prime intention in this design phase is to invoke the interaction between the
two types of managers and observing the possible sets of action selected by each type of the managers to visualize the pattern of erroneous process activity adopted by the EM. Hence, in the proposed framework, the manager $x$ is considered as a manager who can be either IM or EM and manager $y$ as a team member who is always efficient and towards SLA compliance. The managers $(x, y)$ are endowed with a capability to select a specific action from their set of allowed strategies. The model considers EM strategy as $(A_{\text{cop}}, A_{\text{dec}}, A_{\text{rep}})$ and IM strategy as $(A_{\text{risk}}, A_{\text{cop}}, A_{\text{spread}})$. Each manager receives a utility based on own actions, the actions adopted by associated managers, and it’s the type of managers (IM/EM) after completion of each and every phase of the defined process. The utility indices are tabulated in Table 5.3.

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<th>$A_{\text{cop}}$</th>
<th>$A_{\text{dec}}$</th>
<th>$A_{\text{rep}}$</th>
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<tbody>
<tr>
<td>$A_{\text{risk}}$</td>
<td>$(G_{\text{risk}} - C_{\text{risk}}, -G_{\text{risk}} - C_{\text{cop}})$</td>
<td>$(-C_{\text{risk}}, 0)$</td>
<td>$(-G_{\text{rep}} - C_{\text{risk}}, G_{\text{rep}} - C_{\text{rep}})$</td>
</tr>
<tr>
<td>$A_{\text{cop}}$</td>
<td>$(-C_{\text{cop}}, G_{\text{cop}} - C_{\text{cop}})$</td>
<td>$(-C_{\text{cop}}, 0)$</td>
<td>$(-G_{\text{rep}} - C_{\text{cop}}, G_{\text{rep}} - C_{\text{rep}})$</td>
</tr>
<tr>
<td>$A_{\text{spread}}$</td>
<td>$(-C_{\text{spread}}, -C_{\text{cop}})$</td>
<td>$(-C_{\text{spread}}, 0)$</td>
<td>$(-C_{\text{spread}}, -C_{\text{rep}})$</td>
</tr>
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Considering Manager $x$ is IM: (x’s utility, y’s utility)

<table>
<thead>
<tr>
<th></th>
<th>$A_{\text{cop}}$</th>
<th>$A_{\text{dec}}$</th>
<th>$A_{\text{rep}}$</th>
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<tr>
<td>$A_{\text{cop}}$</td>
<td>$(G_{\text{cop}} - C_{\text{cop}}, G_{\text{cop}} - C_{\text{cop}})$</td>
<td>$(-C_{\text{cop}}, 0)$</td>
<td>$(-C_{\text{cop}}, -F - C_{\text{rep}})$</td>
</tr>
<tr>
<td>$A_{\text{dec}}$</td>
<td>$(0, -C_{\text{cop}})$</td>
<td>$(0, 0)$</td>
<td>$(0, -F - C_{\text{rep}})$</td>
</tr>
<tr>
<td>$A_{\text{rep}}$</td>
<td>$(-F - C_{\text{rep}}, -C_{\text{cop}})$</td>
<td>$(-F - C_{\text{rep}}, 0)$</td>
<td>$(-F - C_{\text{rep}}, -F - C_{\text{rep}})$</td>
</tr>
</tbody>
</table>

Considering Manager $x$ is EM: (x’s utility, y’s utility)

The system considers for both the types of managers, all the feasible sets of strategies excluding $A_{\text{dec}}$ that acquires cost. The model interprets cost as the certain amount of resources consumed for implementing a particular new process. Therefore, the IM gains $G_{\text{risk}}$ from successful accomplishment of risk action $A_{\text{risk}}$ which is also dependent on the selection of strategies by the associate managers in different departments. This fact is also supported by the phenomenon of risk of model crash which is made successful when the EM $y$
chooses $A_{\text{cop}}$. However, the IM can also confuse the departments by selecting $A_{\text{cop}}$ in order to mislead the EM $y$. But, in case of single staged process, an IM does not gain by selecting $A_{\text{cop}}$ as its goal (risk) varies from the selected action ($A_{\text{cop}}$). This is totally opposite in case of EM who gains $G_{\text{cop}}$ after adopting action for SLA compliance cooperation $A_{\text{cop}}$.

Another fact is that the EM does not gain anything if action of decline $A_{\text{dec}}$ is adopted. In the final phase of this strategy adoption, when an IM chooses to depart to another department by selecting the action $A_{\text{spread}}$, the IM also estimates the risk of being identified and subsequently penalized by the quality control team. Hence, the model considers anticipated gain for $A_{\text{spread}}$ as the dynamic risk factor that maximizes when the EM $y$ collects the data. In case the EM selects the action $A_{\text{rep}}$, it attains gain value $G_{\text{rep}}$ if the report is positive (that is it has identified $x$ as IM) and the framework is considered as successful in identifying the IM. If the EM adopts the reporting strategy and if the report has been identified as false indication, then the EM faces the threat of damaging the accountability and bearing a loss $F$.

5.2.6. Model's Belief System

The proposed model adopts multi-stage Bayesian process where the EM $y$ will require revising the belief value depending on the progress of process involved in existing software development methodologies. It has been seen that different types of reputation systems deploy Bayesian inference for understanding the trust factor of managers, which is usually categorized into belief and disbelief in the proposed framework. The system thereby deploys the usual update policy for belief $B$ as $\eta_{\text{cop}} / (\eta_{\text{cop}} + \eta_{\text{drop}})$. However, deploying the same standalone actually overlooks the possible cost for false positive, that is critical for the EM to attain sequential rationality.

It has been explored that uncertainty in opinion of type of managers is the prime reason for false positive information generated by EM. The proposed model assimilates the uncertainty-aware reputation system into the decision method of EM and utilize a third factor called $O_{\text{uncer}}$ for signifying
the EM’s opinion towards the other type of manager x: \((\text{Op}_{\text{belief}}, \text{Op}_{\text{disbelief}}, \text{Op}_{\text{uncer}}) \in [0,1]\).

\[
\text{Op}_{\text{belief}} = \eta_{\text{cop}} \div (\eta_{\text{cop}} + \eta_{\text{drop}}) \\
\text{Op}_{\text{disbelief}} = \eta_{\text{drop}} \div (\eta_{\text{cop}} + \eta_{\text{drop}}) \\
\text{Op}_{\text{uncer}} = 12 \cdot \text{Op}_{\text{belief}} \cdot \text{Op}_{\text{disbelief}} \div (\text{Op}_{\text{belief}} + \text{Op}_{\text{disbelief}})^2 \cdot (\text{Op}_{\text{belief}} + \text{Op}_{\text{disbelief}} + 1)
\]

5.2.7. Designing Staged Process

The managers are rational in nature which means that EM will have higher tendency to identify IM and perform reporting action, while IM will adopt a strategy that reduces the possibility of itself getting identified and thereby invoking risk at the organization’s cost. Again, the method does not consider the process being controlled between the two IMs as there is no utility for an IM to do so. In other words, the IM’s capability to identify other IMs is not restricted.

Figure 5.2 illustrates the single stage process, where nature decides the type of manager x, and the type is x’s private information. The manager y possesses current belief formation that x’s type is risky and is signified by the probability factor \(\delta\). Hence, according to Bayes’ rule, \(\delta\) and \((1 - \delta)\) are computed as (Stone, 2013, p. 41):

\[
\delta = \eta_{\text{drop}} \div (\eta_{\text{cop}} + \eta_{\text{drop}}) \\
(1 - \delta) = \eta_{\text{cop}} \div (\eta_{\text{cop}} + \eta_{\text{drop}})
\]

When a new manager joins a department the existing manager within the department assigns preliminary values such as \(\eta_{\text{cop}} = \eta_{\text{drop}} = 1\) (i.e. \(\delta = 0.5\) and \(\text{Op}_{\text{uncer}} = 1\)) for the newcomer, which shows that there is no evidence at this point of time or there is a complete uncertainty in the opinions of the managers.
The proposed model initially considers adopting two types of strategies namely pure strategy and mixed strategy for finding the BNE. Nash equilibrium refers to a situation wherein a manager can benefit from changing the strategy unilaterally when the other manager is continuing with the strategy. Nash equilibrium for a single stage process is referred as BNE. To accomplish complete sequential rationality among the managers in the process, the system aims to explore the perfect Bayesian equilibrium (PBE) of this process as an enhancement to the existing BNE. The discussion of the adopted strategy could be further divided into following:

**Agile Strategy Adoption**

In Agile Strategy formulation, the strategy profile can be represented under two scenarios. In the first case the IM x will always invoke risk ($A_{risk}$) while in the second case it will always invoke cooperation ($A_{cop}$). In the first case the strategy profile of manager x can be represented as:

$$\rho_x = (A_{risk} \text{ if IM}, A_{cop} \text{ if EM})$$

The above formulation would mean that x always adopts $A_{risk}$ if it is IM and $A_{cop}$ if it is EM. Therefore the anticipated payoff $E_y(A_{cop})$ or $E_y(A_{dec})$ of y adopting the Agile Strategy $\rho_y = A_{cop}$ or $\rho_y = A_{dec}$ are:
\[ E_y(A_{\text{cop}}) = \delta \cdot (-G_{\text{risk}} - C_{\text{cop}}) + (1 - \delta) \cdot (G_{\text{cop}} - C_{\text{cop}}) \]

\[ E_y(A_{\text{dec}}) = \delta \cdot 0 + (1 - \delta) \cdot 0 \]

The formulation of \( E_y(A_{\text{cop}}) \) and \( E_y(A_{\text{dec}}) \) basically indexes two cases. In the first case, the associated manager \( x \) is considered as IM. As per manager \( y \)’s existing belief system, this case surfaces with the probability of \( \delta \). As manager \( x \) will adopt \( A_{\text{risk}} \) action, the payoff of manager \( y \) in such situation will be \((-G_{\text{risk}} - C_{\text{cop}})\) and 0 respectively. In the second type of case, \( x \) is a EM surfacing with a probability \((1 - \delta)\). The payoff of manager \( y \) in this situation will be \((G_{\text{cop}} - C_{\text{cop}})\) and 0 respectively. If \( E_y(A_{\text{cop}}) \geq E_y(A_{\text{dec}}) \), the manager \( y \) will choose to adopt \( A_{\text{cop}} \) as the best possible action.

\[ E_y(A_{\text{cop}}) \geq E_y(A_{\text{dec}}) \]
\[ \delta \cdot (-G_{\text{risk}} - C_{\text{cop}}) + (1 - \delta) \cdot (G_{\text{cop}} - C_{\text{cop}}) \geq 0 \]
\[ -\delta \cdot G_{\text{risk}} - \delta \cdot C_{\text{cop}} + G_{\text{cop}} - C_{\text{cop}} - \delta \cdot G_{\text{cop}} + \delta \cdot C_{\text{cop}} \geq 0 \]
\[ \delta \cdot (-G_{\text{risk}} - G_{\text{cop}}) + G_{\text{cop}} - C_{\text{cop}} \geq 0 \]
\[ \delta \cdot (G_{\text{risk}} + G_{\text{cop}}) \leq G_{\text{cop}} - C_{\text{cop}} \]
\[ \delta \leq (G_{\text{cop}} - C_{\text{cop}}) / (G_{\text{risk}} + G_{\text{cop}}) \]

Therefore, when the computed probability \( \delta \leq (G_{\text{cop}} - C_{\text{cop}}) / (G_{\text{risk}} + G_{\text{cop}}) \), the BNE strategy pair for manager \( x \) and \( y \) is:

\[ (\rho_x, \rho_y) = ((A_{\text{risk}} \text{ if IM, } A_{\text{cop}} \text{ if EM}), A_{\text{cop}}) \]

But, this fact changes when \( \delta > (G_{\text{cop}} - C_{\text{cop}}) / (G_{\text{cop}} + G_{\text{risk}}) \) as there is no existence of pure strategy BNE. Consequently, when the IM \( x \) adopts \( A_{\text{risk}} \), the pre-eminent response for manager \( y \) in this case will be to adopt \( A_{\text{dec}} \). But, if the EM \( y \) adopts the action \( A_{\text{dec}} \) then the IM may choose to adopt \( A_{\text{cop}} \) as the best possible reaction as \( C_{\text{risk}} \) may by higher compared to \( C_{\text{cop}} \) in some critical and sensitive scenarios for the IM.

In the second scenario, the IM \( x \) may select Agile Strategy \( A_{\text{cop}} \). In this situation, the EM \( y \)’s best reaction will be to adopt \( A_{\text{cop}} \) without considering for \( \delta \). But, in case EM \( y \) adopts the action \( A_{\text{cop}} \), then the IM may adopt the action \( A_{\text{risk}} \) that minimizes to the prior situation. The profiles may be
represented as \((\rho_x, \rho_y) = ((A_{\text{cop}} \text{ if IM}, A_{\text{cop}} \text{ if EM}), A_{\text{cop}})\) which is definitely not BNE.

**Lean Six Sigma Strategy Adoption**

This phase of discussion considers the possibility of adoption of Lean Six Sigma strategy into the BNE. It was shown in Table 5.1 that \(\phi\) signifies the probability of IM \(x\) to adopt the action \(A_{\text{risk}}\), and \(\psi\) signifies the probability of the EM \(y\) to adopt the action \(A_{\text{cop}}\). Therefore, the anticipated payoff of manager \(y\) while adopting \(A_{\text{cop}}\) and \(A_{\text{dec}}\) is:

\[
E_y(A_{\text{cop}}) = \delta. \phi.(-G_{\text{risk}}-C_{\text{cop}}) + \delta.(1-\phi).(G_{\text{cop}}-C_{\text{cop}}) + (1-\delta).(G_{\text{cop}}-C_{\text{cop}})
\]

\[
E_y(A_{\text{dec}}) = \delta. \phi. 0 + ((\delta.(1-\phi)) + (1-\delta)).0
\]

In order to render selection among \(A_{\text{cop}}\) and \(A_{\text{dec}}\) as it has no impact on EM \(y\)'s utility that is imposing

\[
E_y(A_{\text{cop}}) = E_y(A_{\text{dec}}).
\]

\[
\delta. \phi.(-G_{\text{risk}}-C_{\text{cop}}) + (1-\delta.\phi).(G_{\text{cop}}-C_{\text{cop}})= 0
\]

\[
\delta. \phi.(G_{\text{risk}} + C_{\text{cop}}) = (1-\delta.\phi).(G_{\text{cop}}-C_{\text{cop}})
\]

\[
\delta. \phi.(G_{\text{risk}} + G_{\text{cop}}) = (G_{\text{cop}}-C_{\text{cop}})
\]

\[
\phi = (G_{\text{cop}}-C_{\text{cop}}) / (\delta. (G_{\text{risk}} + G_{\text{cop}}))
\]

Therefore, the IM \(x\)'s strategy for equilibrium will be to adopt the action \(A_{\text{risk}}\) with \(\phi = (G_{\text{cop}}-C_{\text{cop}}) / (\delta. (G_{\text{risk}} + G_{\text{cop}}))\). The anticipated payoff for IM \(x\) for adopting the action \(A_{\text{risk}}\) and \(A_{\text{cop}}\) is respectively as:

\[
E_x(A_{\text{risk}}) = \psi. (G_{\text{risk}}-C_{\text{risk}} ) + (1- \psi) (-C_{\text{risk}}) = \psi. G_{\text{risk}} - C_{\text{risk}}
\]

\[
E_x(A_{\text{cop}}) = - C_{\text{cop}}
\]

Similarly as above, imposing \(E_x(A_{\text{risk}}) = E_x(A_{\text{cop}})\) in order to render the actions \(A_{\text{risk}}\) and \(A_{\text{cop}}\) to have no impact on IM \(x\)'s utility, the equilibrium strategy of EM \(y\) should be to adopt the action \(A_{\text{cop}}\) with probability \(\psi = (C_{\text{risk}} - C_{\text{cop}}) / G_{\text{risk}}\) (when \(C_{\text{risk}} < C_{\text{cop}}, \psi = 0\)). Thus, the Lean Six Sigma strategy pair \((\rho_x, \rho_y) = ((\phi \text{ if IM}, A_{\text{cop}} \text{ if EM}), \psi)\) is a BNE for corresponding situation.
Hence, the BNE of the stage process can be finalized as:

When \( \delta \leq (G_{\text{cop}} - C_{\text{cop}}) / (G_{\text{risk}} + G_{\text{cop}}); \ (\rho_x, \rho_y) = ((A_{\text{risk}} \text{ if IM, } A_{\text{cop}} \text{ if EM, } \text{A}_{\text{cop}}); \) after \( \delta > (G_{\text{cop}} - C_{\text{cop}}) / (G_{\text{cop}} - G_{\text{risk}}), \) the EM y turns a bit conservative and \( (\rho_x, \rho_y) = ((\varphi \text{ if IM, } A_{\text{cop}} \text{ if EM, } \psi). \)

**Proposed Strategy**

When formulating the BNE for a single stage process, \( A_{\text{cop}} \) and \( A_{\text{dec}} / A_{\text{risk}} \) need to be considered. However two important manager’s actions are still left, an EM can report another manager as inefficient by adopting \( A_{\text{rep}} \) while an IM can adopt \( A_{\text{spread}} \) in order to save itself from being caught, which will complete the sequential rationality of the manager. The operations carried out in the proposed strategy are discussed as below:

a. **Designing Reporting Action**

The proposed model considers sequential rationality only in the situation when the anticipated payoff of the manager is higher in the process of its opponent’s strategies. The EM y, after adopting action \( A_{\text{rep}} \) against manager x, can fetch two responses: i) Either manager x was identified to be inefficient and the report was proven as positive or, ii) manager x was found to be a legitimate EM after identification and the report was proven to be a false positive. However, the probability for occurrence of the second event cannot be ruled out if some EMs behave selfishly (i.e., are forced to adopt \( A_{\text{dec}} \) unwillingly because of resource constraints at that particular instance) in certain stages of the process management. EM should attempt to avoid it as a frequent occurrence of such events reduces the capability of the EM to detect the genuine risk of cost overrun. Hence, EM should compute \( F \) (private subjective value exhibiting the EM’s properties) in case of a false positive report. Smaller value of \( L \) point out to the aggressive nature of the EM, while large value of \( F \) depicts a conformist character.

The proposed design considers usage of the threshold factor \( T_{\text{uncer}} \) for accomplishing the best result. \( T_{\text{uncer}} \) illustrates the integration of both the
amounts of identified actions $A_{\text{risk}} / A_{\text{dec}}$ in the evidence and the adequacy of evidence as the same is being levied upon $\delta.(1-Op_{\text{uncer}})$. In order to satisfy the sequential rationality, the EM $y$ should choose to adopt action $A_{\text{rep}}$ only when:

$$E_y(A_{\text{rep}}) > \max \{E_y(A_{\text{cop}}), E_y(A_{\text{dec}})\}$$

where, $E_y(A_{\text{rep}})= \delta.(1-Op_{\text{uncer}}). (G_{\text{rep}}-C_{\text{rep}}) - ((1- \delta)(1-Op_{\text{uncer}})+Op_{\text{uncer}}).(F + C_{\text{rep}})$.

The EM should not be opting for $A_{\text{rep}}$ when $E_y(A_{\text{cop}})>0$. Employing $A_{\text{rep}}$ with $E_y(A_{\text{cop}})>0$ would mean circumventing the possibility of achieving gains from the subsequent stages. Hence, the threshold $T_{\text{uncer}}$ should be computed as the state that forms $E_y(A_{\text{rep}}) > 0$ [5].

$$E_y(A_{\text{rep}}) > 0$$

$$\delta.(1-Op_{\text{uncer}}). (G_{\text{rep}}-C_{\text{rep}}) - ((1- \delta)(1-Op_{\text{uncer}})+Op_{\text{uncer}}).(F + C_{\text{rep}}). > 0$$

$$\delta (1-Op_{\text{uncer}}). (G_{\text{rep}}-C_{\text{rep}}) - (1 - Op_{\text{uncer}} - \delta + \delta.Op_{\text{uncer}} + Op_{\text{uncer}}).(F + C_{\text{rep}}) > 0$$

$$\delta (1-Op_{\text{uncer}}). (G_{\text{rep}}-C_{\text{rep}}) > (1 - \delta + \delta.Op_{\text{uncer}}).(F + C_{\text{rep}})$$

$$\delta (1-Op_{\text{uncer}}). (G_{\text{rep}}-C_{\text{rep}}) + \delta (1-Op_{\text{uncer}}).(F + C_{\text{rep}}) > (F + C_{\text{rep}})$$

$$\delta (1-Op_{\text{uncer}}). (G_{\text{rep}}+F) > (F + C_{\text{rep}})$$

$$\delta (1-Op_{\text{uncer}}) > (F + C_{\text{rep}}) / (G_{\text{rep}}+F).$$

Hence,

$$T_{\text{uncer}} = \frac{F + C_{\text{rep}}}{G_{\text{rep}}+F}$$

Therefore, when $\delta.(1-Op_{\text{uncer}}) > \frac{F + C_{\text{rep}}}{G_{\text{rep}}+F}$, EM $y$ adopts the action $A_{\text{rep}}$.

However, an IM may have dual selections namely:

i) Setting $\varphi < T_{\text{uncer}}$ will render no action of report by an EM irrespective of its uncertainty, and

ii) Setting $\varphi$ as higher to adopt $A_{\text{risk}}$ and $A_{\text{spread}}$ before adopting the action $A_{\text{rep}}$. 

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b. Designing Random Switch Over in Departments

When an IM attempts to switch to some other department \( (A_{spread}) \) after implementing an erroneous process in the software development process, the anticipated gain of the IM will be to avoid getting detected by the EM. The system defines the risk factor as the anticipated loss of being reported. Accordingly Risk\_factor = P (detect).\( G_{rep} \), where P (detect) is the probability of getting detected by the EM. Hence, an IM computes anticipated gain by employing the \( A_{spread} \) as:

\[
E_x (A_{spread}) = Risk\_factor - C_{spread}
\]

When the condition \( E_x (A_{spread}) > \max \{E_x (A_{risk}), E_x (A_{cop})\} \) is met the IM should switch over to a new department by employing the \( A_{spread} \). The IM possesses the precise information about the process management system as well as the costing and hence, it can accurately compute the belief of the EM. The IM is also expected to have sufficient information about the organization as well as complete development manifestos and hence knows the statistical information of loss of false report (\( F \)) for the EM. When there are a large number of managers in multi-national organizations, the false alarm (\( F \)) should comply with the standard distribution. The IM could know the mean (expected value) and standard deviation for (\( F \)) with the network. \( P(detect) \) is equivalent to the probability that the current \( \delta(1-Op_{uncer}) \) will pass EM’s threshold \( T_{uncer} \).

\[
P(detect) = P(\delta.(1-Op_{uncer}) > T_{uncer})
= P(\delta.(1-Op_{uncer}) > (C_{rep}+ F)/(G_{rep}+ F ))
= P( (C_{rep}+ F ) < \delta.(1-Op_{uncer}) . (G_{rep}+ F ))
= P( (F < ((\delta.(1-Op_{uncer}).G_{rep}− C_{rep}))/ (1 - \delta.(1-Op_{uncer}))))
\[
P(F < \frac{\delta(i - Op_{uncer})G_{rep} - C_{rep}}{1 - \delta(1 - Op_{uncer})})
\]

For a generic normal distribution \( f \) with mean \( \mu \) and deviation \( \sigma \), the cumulative distribution function is
\[
F(x) = \phi \left( \frac{x - \mu}{\sigma} \right).
\]

Thus, we have,
\[
P(\text{detect}) = \Phi \left( \frac{\delta(1 - Op_{uncer})G_{rep} - C_{rep} - E(F)}{\sigma(F)} \right)
\]

Where, \( \Phi(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} \exp \left( - \frac{Op_{uncer}^2}{2} \right) dOp_{uncer} \)

Hence, it can be seen that an IM benefits from selecting its optimum value for \( \phi \) when invoking \( A_{risk} \) and later bypass penalization by departing to a new department (\( A_{spread} \)). The IM persistently needs to compute the risk of residing and managing further within a department.

**Manager y’s PBE strategy \( \rho^*_y \)**

A: if \( \delta \geq (1 - Op_{uncer}) / (G_{rep} + F) \)

Report \( x \) as IM by adopting \( A_{rep} \);

go to B;

else

if \( \delta \leq (G_{cop} - C_{cop}) / (G_{cop} + G_{risk}) \)

Adopt \( A_{cop} \) with a probability of 1;

else

Adopt \( A_{cop} \) with a probability of \( (C_{risk} - C_{cop}) / G_{risk} \);

end if

Updated \( \eta_{cop} \) and \( \eta_{drop} \) to evaluate new values for \( \delta \) and \( Op_{uncer} \);

go to A;

B: end if
IM-type Manager x’s PBE strategy $\rho_x^*$

A: if $E_i(F) \geq \max \{E_i(A), E_i(C)\}$
   
   Switch to a new department by adopting $A_{\text{spread}}$;
   
   go to B;

else

   if $(\delta \leq (G_{\text{cop}} - C_{\text{cop}}) / (G_{\text{cop}} + G_{\text{risk}}))$
      
      Adopt $A_{\text{risk}}$ with a probability of 1;

   else
      
      Adopt $A_{\text{risk}}$ with a probability of $(G_{\text{cop}} - C_{\text{cop}}) / (\delta \cdot (G_{\text{risk}} + G_{\text{cop}}))$;

   end if;

   Track EM values for $\delta$ and $O_{\text{uncer}}$;

   Update $E_y(A_{\text{spread}})$;

   go to A;

B: end if

c. Modeling Selfish Behavior

The proposed scheme does not limit the phenomenon of selfishness being exhibited by the EM in some stages of the process which normally should reveal the collaboration always. Existence of selfish managers is being considered, wherein it is assumed that certain EMs may choose to behave selfishly at certain instances. Selfishness may be exhibited due to two reasons: either the manager tries to behave rationally to save its resources or there may be some organizational or personal issues with the EM at particular instances of time. However, in both the cases the common end result is that the EM refuses to take part in the process management leading to the model crash and thus adopting an action of decline ($A_{\text{dec}}$). The selfishness of the managers shall be tried to be included as a discrete quantity in the mathematical model, meanwhile ignoring the sophisticated reasoning of the same. Although, some EMs may behave selfishly only at some events it does not mean that it has a consistent harmful intention for deteriorating the process management system
in an organization. It needs to be clearly understood that there is no degree of selfishness that can approximate the malevolent behavior demonstrated by the IM.

In the proposed system the behavior of the managers is completely governed by the strategies that they are adopting. Hence, the selfishness characteristic also needs to be imposed upon the strategies alone. It was shown in Table 5.1 that SF signifies the degree of selfishness exhibited by an EM. SF represents the possibility of an EM adopting the decline strategy $A_{dec}$ when it should have actually cooperated ($A_{cop}$) based on its current beliefs.

Embedding selfishness into the strategies of an EM:
- Agile strategy will become: $A_{cop}$ with a probability of $(1 - SF)$
- Lean Six Sigma strategy will become: $A_{cop}$ with a probability of $(1 - SF)$. ($(C_{risk} - C_{cop}) / G_{risk}$)

Proposed strategy will become:

A: if $\delta (1 - O_{uncer}) \geq (F + C_{rep}) / (G_{rep} + F)$
   Report x as IM by adopting $A_{rep}$;
   go to B;
else
   if $\delta \leq (G_{cop} - C_{cop}) / (G_{cop} + G_{risk})$
      Adopt $A_{cop}$ with a probability of SF;
   else
      Adopt $A_{cop}$ with a probability of SF. ($(C_{risk} - C_{cop}) / G_{risk}$);
end if

Updated $\eta_{cop}$ and $\eta_{drop}$ to evaluate new values for $\delta$ and $O_{uncer}$;
   go to A;
B: end if

The above formation leads to two implications. Firstly, the EM exhibit selfishness only while playing the cooperate strategy $A_{cop}$. They never exhibit selfishness when they want to report the other manager who has been proved inefficient by adopting $A_{rep}$. This is because the players (managers) will
no longer be completely rational otherwise. This is also in line with the definition of selfishness that the EMs are rational while controlling the process for software development methodologies. Secondly, if the EM is assumed to be always collaborative that is the selfishness factor SF is zero, then there is no actual change in strategies.

d. Assumptions and Dependencies

The main assumption of this model is as follows:

- It is assumed that IMs are also rational who have concerns for their goals which are modeled perfectly, without showing signs of selfishness during any stage of the process.
- It is assumed that managers, by means of passive observation, can track the Scrum logs of the organizational as well as departmental issues.
- It is assumed that the error in observation may occur but with a very low probability. Otherwise, it would be impossible to distinguish an IM just by department monitoring.
- It is assumed that when an IM switches from the department in which it conducted a financial loss, it will also erase all its transaction history in that department thus making the detection process extremely difficult.
- It is assumed that the behavior of the manager cannot be monitored outside the department.
- It is assumed that time is divided into slots and each slot by itself represents a stage of processing.

5.3. Six Sigma Principles in the Quantified Hybrid Model

The present chapter has mainly described the mathematical modeling of the quantified hybrid model using the probability theory and the strategic decision making theory. Referring to Figure 5.2 it can be seen that the proposed system considers adopting Process Map, C&E Matrix, Measurement System Analysis, Capability Analysis, Multivariate Analysis, Statistical Process Model, and Failure Mode & Effect Analysis as the tools to implement
Six Sigma. The entire success of the mathematical model discussed in this chapter depends on the accuracy of Six Sigma tool selection. Therefore, the proposed quantified hybrid model adopts such statistical tools for transforming raw data into specific and clear information, which are also part of the core design principles of the Six Sigma methodologies being implemented. Extensive mathematical analysis is performed by using the game theory to verify the level of adherence of SLA compliance by the efficient managers and to discourage the inefficient managers by offering them a small payoff if their decisions were not productive. Lesser values of uncertainty in the quantified hybrid model will ensure a higher level of customer satisfaction. The outcome of it is also verified using the Cost of Poor Quality in the next chapter, thereby proving the effectiveness of using Six Sigma as the backbone of the proposed quantified hybrid model.

5.4. Summary

This chapter has discussed the important modeling components that are used for designing the proposed framework. The chapter highlights the various actions and strategies to be formulated in the simulation study considering the IMs and the EMs. The framework is discussed with respect to the clustering technique applied, designed decision model, and adopted specifications of the game with supporting empirical structures. The outcome of this chapter is elaborated in the next chapter.