Getting to Win-Win in Industrial Collaboration Under Coopetition: A Strategic Modeling Approach

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Abstract. Interorganizational coopetition describes a relationship in which two or more organizations cooperate and compete simultaneously. Actors under coopetition cooperate to achieve collective objectives and compete to maximize their individual benefits. Such relationships are based on the logic of win-win strategies that necessitate decision-makers in coopeting organizations to develop relationships that yield favorable outcomes for each actor. We follow a strategic modeling approach that combines *i** goal-modeling to explore strategic alternatives of actors with Game Tree decision-modeling to evaluate the actions and payoffs of those players. In this paper, we elaborate on the method, illustrating one particular pathway towards a positive-sum outcome - through the introduction of an intermediary actor. This paper demonstrates the activation of one component in this guided approach of systematically searching for alternatives to generate a new win-win strategy. A hypothetical industrial scenario drawn from practitioner and scholarly literatures is used to explain this approach. This illustration focuses on the Industrial Data Space which is a platform that can help organizations to overcome obstacles to data sharing in a coopetitive ecosystem.

Keywords: Coopetition · Win-Win · Design · Modeling

1 Introduction

Coopetition refers to concomitant cooperation and competition among actors wherein actors "cooperate to grow the pie and compete to split it up" [1]. Actors under coopetition simultaneously manage interest structures that are partially congruent and partially divergent [2]. Partial congruence emerges from actors sharing in certain common objectives while partial divergence emanates from each actor's pursuit of self-interest. Coopetition has become "increasingly popular in recent years" [3] and is widely observed in various domains including business, politics, and diplomacy [4].

Coopetition is predicated on the rationale of positive-sum outcomes through which all actors are better off by coopeting rather than by purely competing or solely cooperating. This aspect of coopetition requires decision-makers in coopeting organizations to develop and analyze win-win strategies. We apply a synergistic approach that combines *i** goal-modeling with Game Tree decision-modeling to generate and

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discriminate win-win strategies in a structured and systematic manner. In [32], we illustrated a win-win scenario arrived at by generating a new alternative for achieving a goal, using the means-ends reasoning supported by *i** goal-modeling. In this paper, we illustrate a different pathway to get to win-win by introducing a new actor within an existing relationship between two actors. We use a hypothetical industrial scenario adapted from practitioner and scholarly literatures to explain this approach.

Coopetition research originated in the field of economics where researchers applied concepts from game theory to explain the motivations of coopeting actors [5]. According to game theory, three types of results are possible in strategic relationships between players: positive-sum, zero-sum, and negative-sum [6]. In positive-sum outcomes all players are better off and in negative-sum outcomes all players are worse off [6]. In zero-sum outcomes the amount of gain by some players equals the amount of loss by other players.

These outcomes are correlated to distinct types of strategies that are adopted by players in coopetitive relationships: win-win, win-lose, and lose-lose. Win-win strategies are the only durable options for sustaining coopetitive relationships. Win-lose strategies are unsustainable in coopetitive relationships because some actors (i.e., those that are disadvantaged) will be worse off as a result and these actors are likely to withdraw from or abandon such relationships.

2 Motivating Example: Interorganizational Knowledge-Sharing in Pharmaceutical Industry

Drug discovery and biopharmaceutical development is characterized by long innovation cycles and high capital requirements. Pharmaceutical companies share knowledge with each other to accelerate "product development processes", "reduce costs", and increase "development productivity" [9]. Coopetitive relationships within research and development (R&D) alliances in the pharmaceutical industry are described in [9]. The complexity of interorganizational knowledge-sharing in the pharmaceutical industry is discussed in [10, 11].

Knowledge-sharing can expose members of R&D alliances to the risk of knowledge expropriation through knowledge leakage [10, 11]. This is because R&D alliances can be among firms that are competitors in the marketplace. Such firms are coopetitors because they cooperate in the R&D domain but compete for customers in the marketplace. Knowledge leakage occurs when a "focal firm's private knowledge is intentionally appropriated by or unintentionally transferred to partners beyond the scope of the alliance agreement" [12]. Knowledge expropriation is an opportunistic behavior [13, 14] that is motivated by the desire of firms to engage in 'learning races' [15, 16] to 'learn faster' [17, 18] than each other in the pursuit of 'competitive advantage' [19, 20]. Knowledge management researchers refer to this phenomenon as 'boundary paradox' and 'learning paradox' [48].

The potential for knowledge expropriation through knowledge leakage implies that simple knowledge-sharing under cooperation can lead to win-lose or lose-lose outcomes. In such a scenario, no immediate solutions might exist for the firms under coopetition to get to positive-sum outcomes. Subject matter experts (SMEs) and domain specialists in such firms might contemplate different pathways for generating win-win strategies. For example, one option might be for coopeting firms to engage other actors, illustrated in Sect. 3 in this paper, into their relationship to help reduce opportunities for exploitation. Another option might be for coopeting firms to jointly develop and operate knowledge-sharing systems in-house that mitigate the risks of knowledge misappropriation. Yet another option might be for the actors to change their motivations to disincentivize opportunistic behavior through rewards and penalties.

The pathway selected by SMEs in coopeting firms will depend on the specifics of their firms as well as their relationships. In the real-world, the process of generating and discriminating among such options is complex and nontrivial due to two main reasons [7]. First, the decision space of each actor is constrained or enlarged by interdependencies with potential actions of other actors. Second, trade-offs between multiple competing objectives lead to different prioritization of alternatives by each actor due to the unique preference structure of that actor.

3 Modeling Win-Win Strategies Using *i** and Game Trees

3.1 Framework with *i** and Game Trees for Modeling Win-Win Strategies

In this paper, we illustrate the use of a mediating actor to get to win-win by applying the modeling approach that is depicted in Fig. 1. This process interleaves steps from *i** and Game Tree modeling in an incremental and iterative manner. It is useful for co-developing complementary models that jointly offer greater 'interpretability' and 'explainability' than either can individually. *i** (denoting distributed intentionality) is a *goal*- and *actor*-oriented modeling language that supports strategic reasoning. The semantics and notation of *i** are explained in [8].

Game Trees are decision trees that support representation of decisions and *payoffs* associated with *actors* in a *game*. In Game Theory, a *game* refers to any social situation in which two or more *players* are involved. A *player* is an active participant in a strategic relationship with one or more *players*. A *payoff* is the *reward* (positive) or *penalty* (negative) associated with a specific course of action. A course of action is a sequence of decisions and actions undertaken by the players in a *game*. Solving a game refers to selecting a *reward* maximizing or *penalty* minimizing strategy for one or more *players*. The characteristics and features of Game Trees are described in [6].

It is noted in [7] that, "while game trees support the depiction of payoffs they do not explicitly codify the reasons for those payoffs". However, "even though the internal intentional structure of an actor cannot be expressed directly in Game Trees it can be represented via *i** Strategic Rationale (SR) diagrams" [7]. In [7, 32], *i** SR diagrams are used to represent and reason about internal intentional structures of *actors* while Game Trees are used to express and evaluate decisions and *payoffs* of those players. Therefore, "Game Trees and actor modeling with *i** can be used together to achieve a deeper understanding of the decision space as well as to secure a stronger decision rationale" [7].

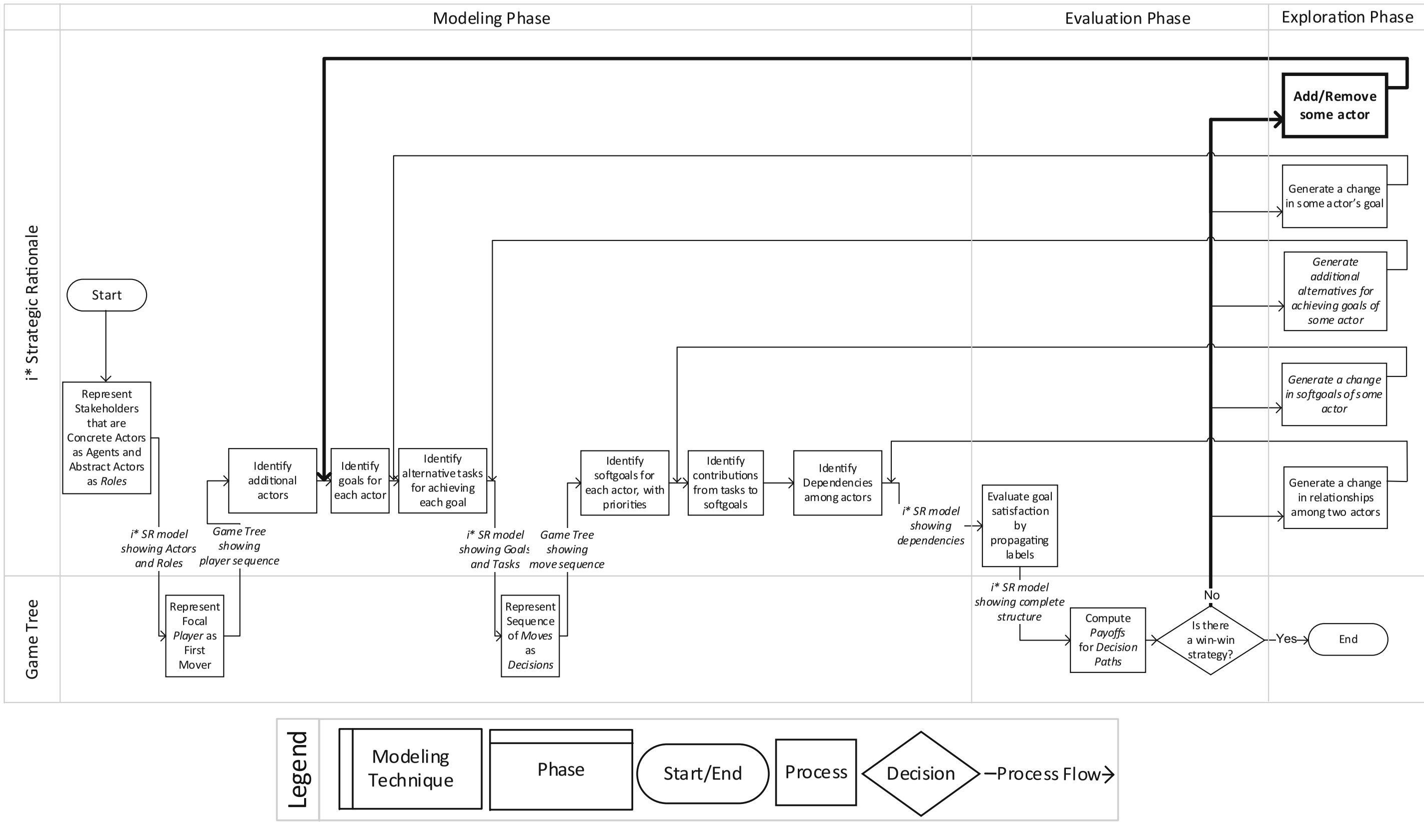


Fig. 1. Process steps for alternating between *i** and Game Tree modeling to get to win-win (Introduction of new **actor** is highlighted in **bold**, *softgoal* and *tasks* in *italics*)

This process, which is depicted in Fig. 1, comprises three phases: Modeling, Evaluation, and Exploration. In the Modeling phase, an *i** SR diagram and its corresponding Game Tree are instantiated and populated. In the Evaluation phase, the impacts of various choices on objectives are calculated to detect the presence of any extant win-win strategies. In the Exploration phase, a systematic search is performed to generate new alternatives that yield positive-sum outcomes. This process can be repeated to generate as many win-win strategies as necessary.

Modeling Phase: In this phase, strategic relationships among *actors* are modeled in terms of *goals*, *tasks*, *resources*, *softgoals*, and *dependencies* among them that are denoted in an *i** SR diagram. The sequence of decisions and *payoffs* of these *players* are codified in a Game Tree. An *actor* is an active entity that performs actions by applying its know-how to accomplish its *goals*. A *goal* is a state of affairs in the world that an *actor* wishes to achieve. *Task* is a concrete method for addressing a *softgoal* to satisfy some requirements. In *i**, *softgoals* denote quality objectives that do not have clear-cut satisfaction criteria. They are evaluated as being satisfied or denied from the subjective perspective of an *actor*.

A *task* is an activity that can be used to accomplish a *goal*. The relationship between a *goal* and its associated *tasks* is shown via *means-ends* links. A *goal* (the "end") is achieved when any of its associated *tasks* (the "means") are completed. A *task* can be decomposed into subsidiary *goals*, *tasks*, *softgoals*, and *resources*. A *resource* is a physical or informational entity that is necessary for completing a *task*. The relationship between a task and its subsidiary entities is depicted via a *task-decomposition* link. In *i**, a *depender* depends on a *dependee* for a *dependum*. A *dependum* can be a *goal* to be achieved, *task* to be completed, *softgoal* to be satisfied, or *resource* to be obtained.

Contribution links relate *tasks* to *softgoals* and *softgoals* to other *softgoals*. *Contribution links* can be of type *Help* (denoted by a green line accompanied with a plus symbol) or *Hurt* (denoted by a red line accompanied with a minus symbol). A *Help contribution link* contributes positively towards the achievement of a *softgoal*. A *Hurt contribution link* contributes negatively towards the achievement of a *softgoal*. Contributions can be intentional (denoted by a solid line) or incidental (denoted by a dashed line). Further details about i* modeling can be found in [8].

Evaluation Phase: In this phase, *Contribution links* are used to propagate and trace the impact of lower-level *tasks* and *softgoals* on higher-level *softgoals*. *Softgoals* can either be fully satisfied (denoted by a checkmark) or partially satisfied (denoted by a dot underneath a checkmark). Conversely, *softgoals* can either be fully denied (denoted by a cross) or partially denied (denoted by a dot underneath a cross).

Forward propagation of labels can be used to answer 'is this solution viable' type of questions. The process for forward propagation of satisfaction labels in goal models is explained in [27]. This process involves the iterative application of propagation rules to attach current values from each offspring to its parent and then resolving *softgoal* labels at the parent level [27]. We apply the rules for satisfaction analysis in goal models that are explained in [28, 29] in the Evaluation phase.

3.2 As-Is Scenario: Discriminating Win-Win Strategies with *i** and Game Trees

Modeling Phase: Figure 2 presents a goal model of an As-Is knowledge-sharing scenario between firms under coopetition. This goal model focuses on interdependencies among *softgoals*, and *tasks* that operationalize those *softgoals* while deferring consideration of relationships among actors. In this goal model, the nodes are *softgoals* or *tasks* while the edges are *contribution links*. Tables 1 and 2 expand on the meanings of these *softgoals* and *tasks*.

In this industry scenario, a firm has two top-level *softgoals* which are “No Leakage” of knowledge assets and “No Blocking” of knowledge transfers. “No Leakage” of knowledge assets is a *softgoal* because separate firms may judge the presence or absence of knowledge leakage differently. Similarly, “No Blocking” of knowledge transfers is another *softgoal* because different firms may use dissimilar criteria to determine whether or not knowledge-sharing is being blocked.

A firm can adopt a Strict knowledge-sharing policy or a Permissive knowledge-sharing policy. A Strict policy prioritizes minimization of knowledge-leakage over circumvention of knowledge-blocking. Conversely, a Permissive policy treats avoidance of knowledge-blocking with greater importance than prevention of knowledge-leakage.

In the knowledge sharing setting considered here, the same goal model applies equally to all sharing parties. In other settings, a separate goal model may be needed to represent the perspective of each actor.

Softgoals are operationalized by *tasks* (bottom of Fig. 2). For example, “Processing” involves generating machine-readable metadata for each knowledge asset. This makes it easier to distinguish among individual knowledge assets such as on the basis of their ownership. Therefore, “Processing” is a *task* that operationalizes the *softgoal* “Annotatable” asset ownership. Similarly, “Integrating” involves mixing together knowledge assets from various partners. This makes it simpler for each firm to avail of the knowledge of their partners. Therefore, “Integrating” operationalizes the *softgoal* “Available” partner assets.

In this example, we use the notation wherein the inclusion of a *task* in a Strict or Permissive policy is inscribed within each *task*. A circle inscribed with an S and a numerical identifier in the top left corner of a *task* denotes the inclusion of that *task* in a Strict policy. A square inscribed with a P and a numerical identifier in the top right corner denotes the inclusion of that *task* in a Permissive policy. For example, “Auditing” of knowledge transfers is a part of a Strict policy and “Integrating” of partner assets is a part of a Permissive policy.

A *task* can also be included simultaneously in Strict and Permissive policies while being implemented differently in each policy type. For instance, “Modularizing” the boundary of a knowledge asset is part of both Permissive as well as Strict policies even though modularization may be implemented differently in Strict and Permissive policies. It should be noted that these inscriptions (i.e., S with identifier in circle on top left of *task* and P with identifier in circle on top right of *task*) are specific to this example.

Table 1. *Softgoal* types and topics in As-Is scenario in Fig. 2

Softgoal type [Topic]	Description of *softgoal*
No Leakage [Knowledge Assets]	Assets should not be misappropriated by partners [10, 11]
No Blocking [Knowledge Transfers]	Transfers should be seamless and frictionless [42, 43]
Synergetic [Knowledge Assets]	Assets should be more valuable jointly than individually [21, 22]
Leveragability [Knowledge Assets]	Assets should be useful and usable to generate benefits [21, 22]
No Negative Cross Impact [A. Val.]	Sharing with partner should not reduce value of asset for self [21, 22]
Interdependence [Bus. Partners]	Sharing should take place among co-dependent partners [22]
Complementarity [Partner Assets]	Partner assets should enhance each other's asset value [23]
Transferability [Knowledge Assets]	Assets should be distributable to partners [40]
Appropriability [Knowledge Assets]	Assets should be receivable by partners [14]
Irreducible [Asset Value]	Benefits from asset should be indestructible and renewable [45]
Protectable [Knowledge Assets]	Assets should be containable and isolatable [41]
Mutuality [Partner Assets]	Sharing should encompass assets that are inter-reliant [44]
Annotatable [Asset Ownership]	Identity of the owner of each asset should be discernible [48]
Combinable [Partner Assets]	Assets should be integrable with other assets [50]
Compatible [Knowledge Assets]	Assets should function normally in conjunction with other assets [46]
Available [Partner Assets]	Assets should be easily reachable when needed [47]
Absorbable [Partner Assets]	Assets should be easily consumable when needed [14]
Dynamic [Knowledge Assets]	Content and functionality of asset should be changeable [45]
Concealable [Asset Content]	Asset contents should be capable of being hidden from partners [48]
Licensable [Knowledge Assets]	Assets should support deactivation and decommissioning [49]

Goal models aid in detecting and analyzing tradeoffs that exist among different *softgoals*. The goal model in Fig. 2 shows that various *tasks* impact *softgoals* differently. For instance, "Posting" a knowledge asset into an asset directory *Helps* to make that knowledge asset more "Combinable" (i.e., easier to integrate) with other knowledge assets. Conversely, "Modifying" the behavior of a knowledge asset can make it less "Compatible" with knowledge assets with which it is already interoperable (i.e., *Hurts* link). Specific combinations of *tasks* within a Strict or Permissive policy can also

Table 2. *Task* types and topics in As-Is scenario in Fig. 2

Task type [Topic]	Policy	Description of *task*
Auditing [Knowledge Transfers]	S	Reviewing actions performed by users and processes [48]
Processing [Asset Metadata]	S	Generating machine-readable metadata for each asset [54]
Exposing [Asset Interface]	P	Registering input and output parameters of an asset [51]
Documenting [Asset Schema]	P	Explaining types of entities and relationships in an asset [40]
Integrating [Partner Assets]	P	Commingling content from disparate partner assets [53]
Publishing [Asset Directory]	P	Advertising sharing of an asset via a repository [51]
Modifying [Asset Behavior]	S	Reprogramming the content and functionality of an asset [56]
Modularizing [Asset Boundary]	S, P	Setting perimeter of each asset specifying its scope [55]
Reconfiguring [Knwldg. Assets]	S	Asset should be packagable in many ways [52]

impact softgoals differently. For instance, “Auditing” is a *task* that is part of a Strict policy and operationalizes the *softgoal* “Mutuality” of partner assets. It also *Helps* the *softgoal* “Licensable” knowledge assets. Similarly, “Reconfiguring” of knowledge assets is a *task* that is also part of a Strict policy and operationalizes the *softgoal* “Licensable” knowledge assets. This *softgoal* “Licensable” knowledge assets is considered to be satisfied in a Strict policy since multiple *tasks* that are part of a Strict policy make positive contributions to it. Conversely, the *softgoal* “Dynamic” knowledge assets is only partially satisfied in a Strict policy due to the conflicting interaction of two *tasks* which are part of a Strict policy. These are “Modifying” asset behaviour and “Processing” asset metadata. While “Modifying” asset behavior operationalizes the *softgoal* “Dynamic” knowledge assets this *softgoal* is *Hurt* by “Processing” asset metadata.

In the real world, each actor assesses such trade-offs between *softgoals* in line with its preferences and prioritizes those *softgoals* differently depending on its proclivities. The goal model in Fig. 2 is instantiated in Fig. 3 to demonstrate this with respect to two *actors* in a coopetitive relationship. Figure 3 depicts co-developed *i** SR diagram and Game Tree of the As-Is scenario pertaining to two business partners in the pharmaceutical industry.

In this *i** diagram, Branded Pharmaceutical Company (BPC) and Generic Pharmaceutical Compounder (GPC) are two *actors*. BPC develops and markets prescription medicines based on its R&D initiatives as well as its protected intellectual property (IP) (not shown[1]). GPC manufactures ingredients that are used in BPC’s medicines and

[1] In this instance, and in the remainder of this paper, certain aspects of the relationship between actors are not shown due to page limitations.

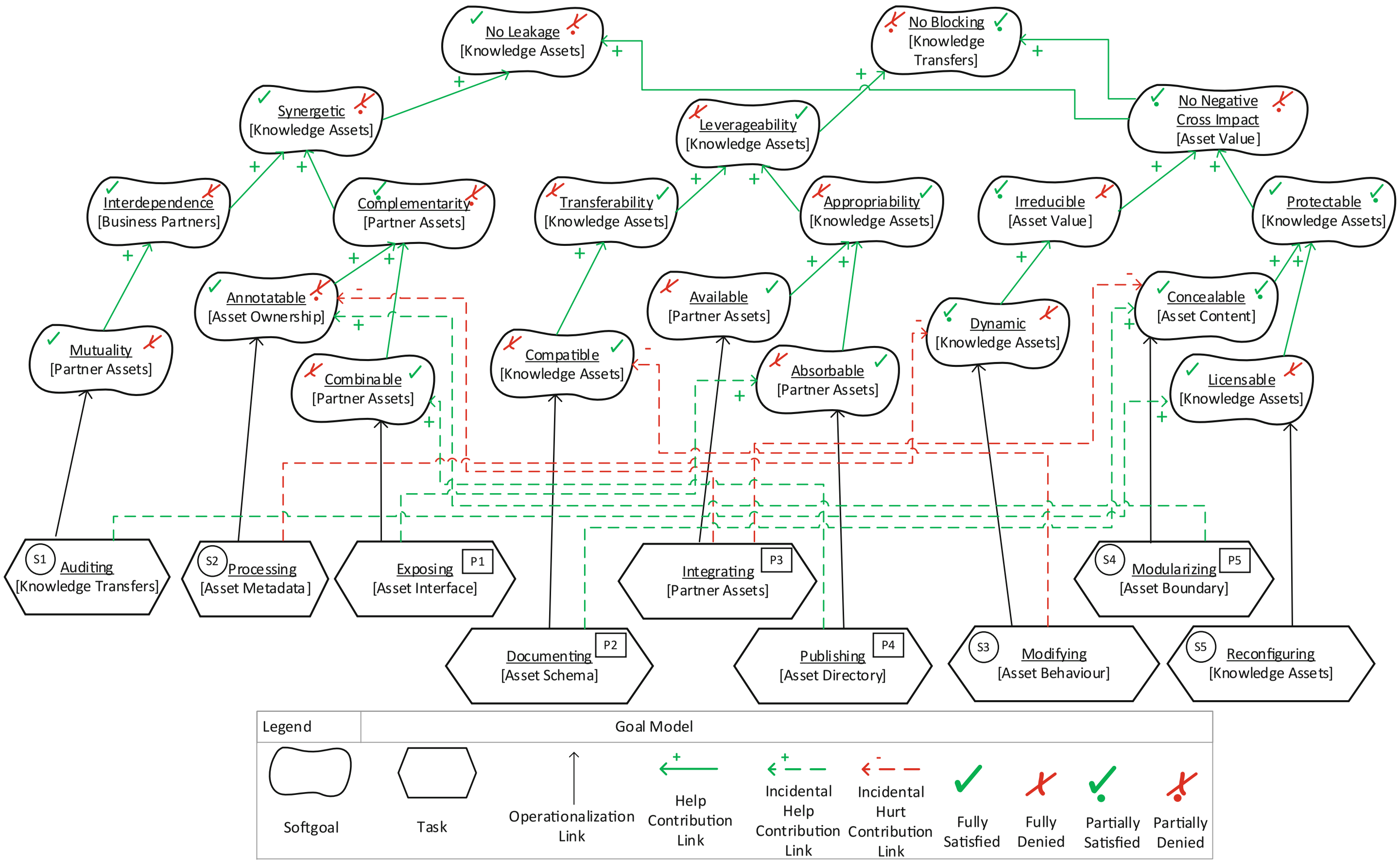
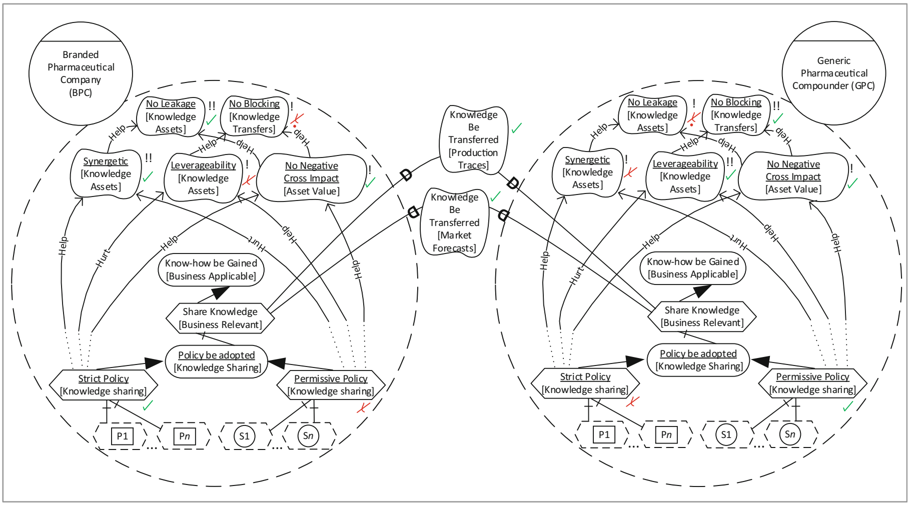
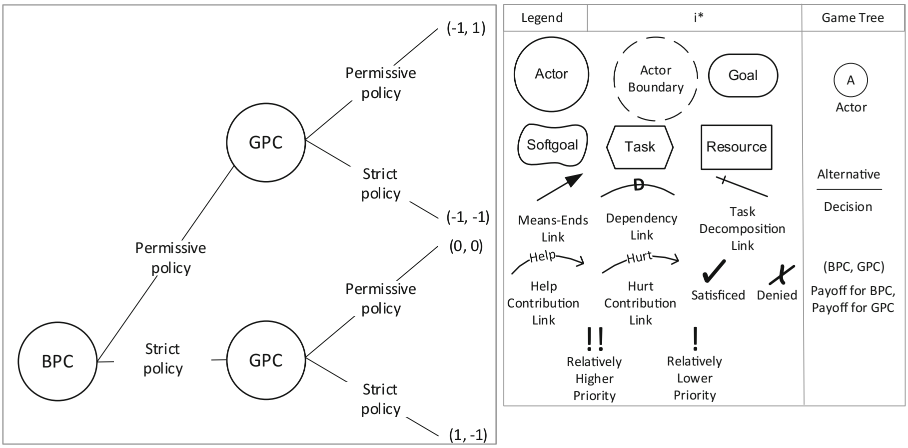


Fig. 2. Goal model of As-Is scenario representing knowledge sharing goals and potential tasks, synthesized from [21–26] – the As-Is scenario



(i) *i** SR diagram showing strategic goals of the two coopeting *actors*



(ii) Game Tree showing *payoffs* from possible moves by BPC followed by GPC moves

Fig. 3. As-Is scenario

produces medicines for BPC that BPC sells in the market (not shown, see footnote 1). GPC also sells generic medicines that are analogous to the prescription medicines sold by BPC only if their IP is not protected (not shown, see footnote 1).

The two *actors* depend on each other to meet their respective *goals* pertaining to "Know-how be Gained". GPC depends on "Market Forecasts" of BPC (shown) so that *GPC* can approximate the upcoming requirements of BPC (not shown, see footnote 1). This helps *GPC* to plan its production runs based on medicines that *BPC* will likely contract *GPC* to produce (not shown, see footnote 1). BPC depends on the "Production Traces of GPC" (shown) to verify that GPC is only manufacturing those quantities of ingredients of BPC's high margin medicines that are ordered by BPC (not shown, see footnote 1). This helps BPC to verify that GPC is not manufacturing extra quantities of those ingredients to produce substitute medicines that GPC can sell by itself (not shown, see footnote 1).

Dependencies among BPC and GPC are shown as *softgoals* because each is satisficed from the perspective of the *depender*. Both *actors* can achieve their respective *goals* of "Know-how be Gained" by performing the *task* "Share Knowledge". Knowledge sharing *"Policy be adopted"* is a sub-*goal* of this *task* "Share Knowledge". This sub-*goal* is associated with two *tasks* which pertain to the adoption of either a "Strict" or a "Permissive" knowledge sharing policy. The *tasks* labeled "Strict Policy" and "Permissive Policy" for knowledge sharing in Fig. 3 map to the set of *tasks* in Fig. 2 with the inscriptions of S and P respectively. This is shown in Fig. 3 via the decomposition of two *tasks*, which are "Strict Policy" and "Permissive Policy", into their respective sub-tasks, which are denoted by "$P_1 \ldots P_n$" and "$S_1 \ldots S_n$". Contributions from the *tasks* labeled "Strict Policy" and "Permissive Policy" to *softgoals* labeled "Synergetic" knowledge assets, "Leveregeability" of knowledge assets, and "No negative-cross impact" of asset value are depicted indirectly via a partially dotted *contribution link*. This is done to hide the full intentional structure in the *i** SR diagram since the complete goal model in Fig. 2 contains these details.

Potential benefits from knowledge sharing serve as incentives for BPC and GPC to adopt "Permissive" policies. However, the countervailing threat of opportunism serve as motivations for BPC and GPC to adopt "Strict" policies. Since BPC and GPC are autonomous actors they are free to select either Permissive or Strict policy in line with their preferences and proclivities. In this example, as shown in Fig. 3, BPC prioritizes a "Strict" policy over a "Permissive" policy while GPC prioritizes a "Permissive" policy over a "Strict" policy. The selection of one policy over another in the real-world is likely to be the result of deliberation and contemplation by subject matter experts (SMEs) and domain specialists. This modeling approach complements and supplements their reasoning and analysis rather than substitute or obviate it.

Evaluation Phase: In the Evaluation phase, *payoffs* in the Game Tree are estimated by analyzing *softgoal* satisfaction in the *i** SR diagram. A preliminary analysis of *softgoal* satisfaction in the goal model in Fig. 2 reveals that neither Strict nor Permissive knowledge-sharing policies satisfy all top-level *softgoals* in the As-Is scenario. The *i** SR diagram in Fig. 3 shows that neither BPC nor GPC satisfy every *softgoal* through their chosen policies. For example, BPC is not able to satisfy one of its top-level *softgoals* of "No Blocking" of knowledge transfers by choosing a Strict policy while GPC is not able to satisfy one of its top-level *softgoals* of "No Leakage" of knowledge assets by choosing a Permissive policy. The *i** SR diagram in Fig. 3 can be used to calculate the relative *payoffs* for these *players* in the Game Tree.

On the Game Tree, in the first case, BPC and GPC select Permissive policies. Since GPC prioritizes a top-level *softgoal* that is satisfied when this type of policy is chosen then it earns a *payoff* of 1. However, BPC prioritizes a top-level *softgoal* that is denied when this policy is chosen then it earns a *payoff* of −1. In the second case, BPC selects a "Permissive" policy but GPC selects a "Strict" policy. In this case neither BPC nor GPC achieve their higher priority top-level *softgoals* and thus both earn payoffs of −1. In the third case, BPC selects a "Strict" policy but GPC selects a "Permissive" policy. In this case while both BPC and GPC satisfy their higher priority top-level *softgoals* they do not satisfy some of their, albeit lower priority, *softgoals*. Thus, both earn payoffs of 0. In the fourth case, BPC and GPC select "Strict" policies. Since BPC prioritizes a top-level *softgoal* that is satisfied when this type of policy is chosen then it earns a *payoff* of 1. However, GPC prioritizes a top-level *softgoal* that is denied when this type of policy is chosen then it earns a *payoff* of −1.

These *payoffs* in the Game Tree can be used to detect the presence of any positive-sum outcomes. In the As-Is scenario, there are no win-win strategies since neither "Permissive" nor "Strict" policies allow BPC and GPC to satisfy each of their top level *softgoals*. This motivates their systematic search for new alternatives to generate positive-sum outcomes.

3.3 To-Be Scenario: Generating Win-Win Strategies with *i** and Game Trees

Exploration Phase: In the Exploration phase, an SME can pursue any of five non-deterministic lines of action incrementally and iteratively. As depicted in Fig. 1, they can add/remove some *actor*, generate additional alternatives for achieving *goals* of some *actor*, generate a change in relationships among some *actors*, generate a change in *softgoals* of some *actor*, or generate a change in some *actor's goals*. For example, as shown in the goal model in Fig. 4, new *softgoals* and *tasks* can be introduced that favorably impact (i.e., *Help*) top-level *softgoals*. These new *softgoals* and *tasks* can be used to satisfy previously denied top-level *softgoals*.

Figure 4 is a goal model of a hypothetical To-Be knowledge-sharing scenario between businesses under coopetition. Model elements, from the As-Is scenario in Fig. 2, that are unimpacted by new *softgoals* and *tasks* in Fig. 4 are greyed-out. This improves the presentation of the goal model to highlight the To-Be scenario. New *softgoals* and *tasks* in Fig. 4 are shown in blue color while existing *softgoals* that are impacted by new *softgoals* and *tasks* are shown in black color. New *contribution links* are shown in green (Help) and red (Hurt) colors while existing contribution links are greyed-out. We anticipate that, with tool support in the future, one would be able to collapse or expand portions of the model to hide or reveal details as necessary.

Loops in the process depicted in Fig. 1 indicate that any step in the Exploration phase of this modeling approach can trigger other steps. For example, in the pursuit of a win-win strategy, an SME may decide to generate new *tasks* to improve overall satisfaction of top-level *softgoals*. These new *tasks,* depicted in Fig. 4, may trigger the generation of new *softgoals*. Collectively, these additional tasks and softgoals represent new system requirements that expand the set of existing system requirements depicted in Fig. 2.

Tables 3 and 4 describe these new *softgoals* and *tasks*. However, their sources are not listed due to constraints on paper length. These new requirements can be fulfilled by performing certain activities in-house (i.e., generate additional alternatives for achieving goals of some actor). Alternatively, they can be fulfilled by including a new actor into the existing relationship (i.e., add/remove some actor). If needed, the pros and cons of each option in the Exploration phase can also be modeled with *i** separately.

Table 3. Softgoal types and topics and topics in To-Be scenario in Fig. 4

Softgoal type [Topic]	Description of *softgoal*
Balanced [Asset Sharing]	Quantity of contents transferred should be equal among partners
Reportable [Asset Sharing]	Quantity and quality of contents transferred should be auditable
Compliant [Knowledge Assets]	Format of assets should be consistent with third-party specifications
Redundant [Knowledge Assets]	Copies of assets should be stored for safeguarding

Table 4. Task types and topics in To-Be scenario in Fig. 4

Task type [Topic]	Policy	Description of *task*
Metering [Knowledge Transfers]	S	Measuring quantity of transfers between partners
External Tracking [Knowledge Transfers]	P	Surveilling content in transfers between partners
Canonical Template [Knowledge Model]	S	Establishing uniform format to be used by partners
Certifying [Asset Specification]	P	Attesting system specification by standards organization
Replicating [Knowledge Assets]	S, P	Creating multiple copies of asset

Evaluation Phase: The *i** SR diagram in Fig. 5 can be used to calculate the relative *payoffs* for the *players* in the Game Tree. In the first case, BPC and GPC select Permissive policies. Since all top-level *softgoals* of GPC are satisfied and it acts in accordance with its preference (i.e., adopts Permissive policy) then it earns a *payoff* of 2. Each top-level *softgoal* of BPC is also satisfied in this case but since it does not act in line with its preference (i.e., does not adopt Strict policy) then it earns a *payoff* of 1. In the second case, BPC selects a Permissive policy but GPC selects a Strict policy. In this case both BPC nor GPC achieve their higher priority top-level *softgoals* but neither acts according to their preferences and thus both earn payoffs of 1. In the third case, BPC selects a Strict policy but GPC selects a Permissive policy. In this case both BPC and GPC satisfy each of their higher priority top-level *softgoals* and act according to their preferences. Therefore, both earn payoffs of 2. In the fourth case, BPC and GPC select Strict policies. Since all top-level *softgoals* of BPC are satisfied and it acts in accordance with its preference (i.e., adopts Strict policy) then it earns a *payoff* of 2. Each top-level *softgoal* of BPC is also satisfied in this case but it does not act in line with its preferences (i.e., does not adopt Permissive policy) then it earns a *payoff* of 1.

The *i** SR diagram of the To-Be scenario shows that all the top-level *softgoals* of BPC and GPC are satisfied. This is due to their addition of new *softgoals* and *tasks* as well as the introduction of a new *actor*, which is IDS. Therefore, the *payoffs* associated with the To-Be scenario in the Game Tree reflect higher values than their corresponding

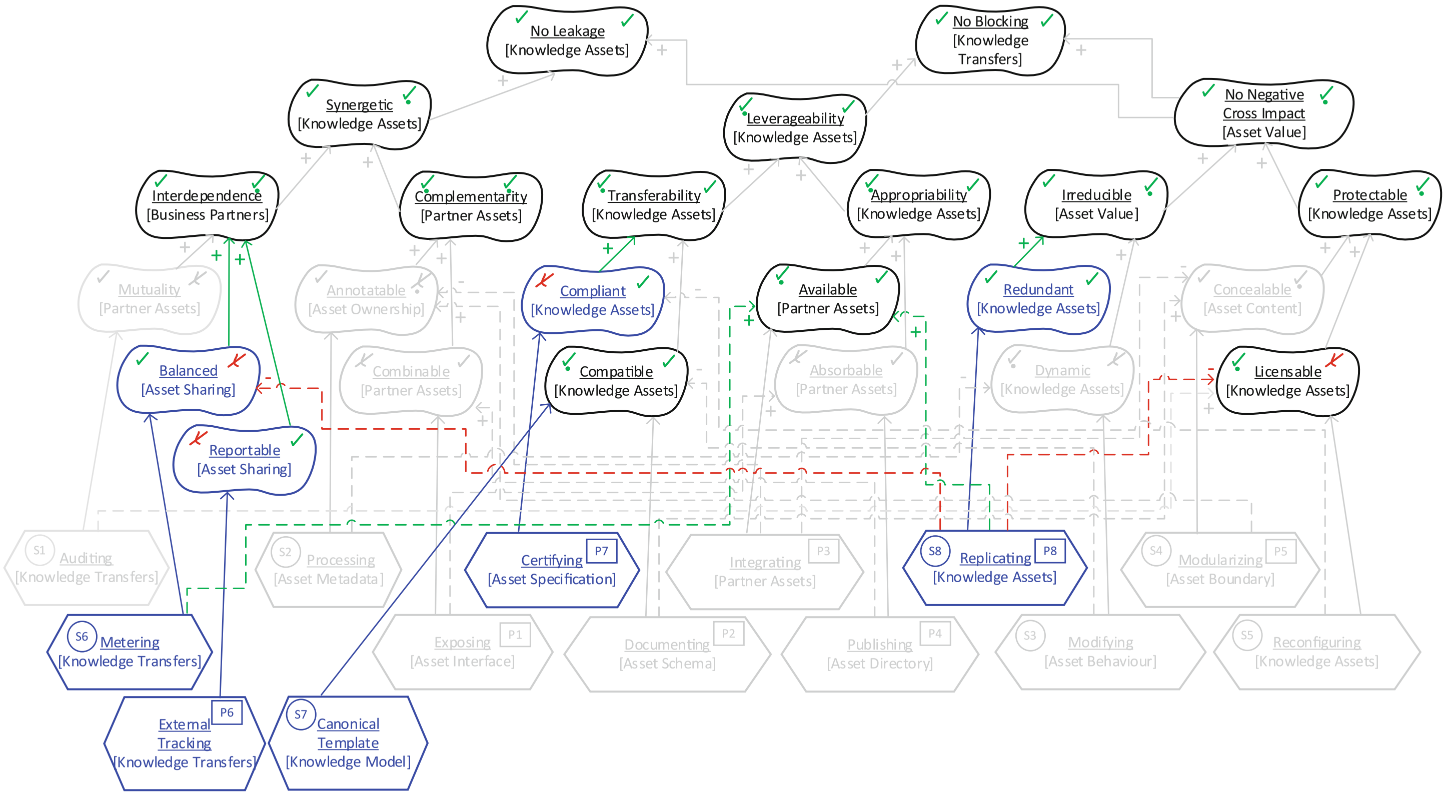
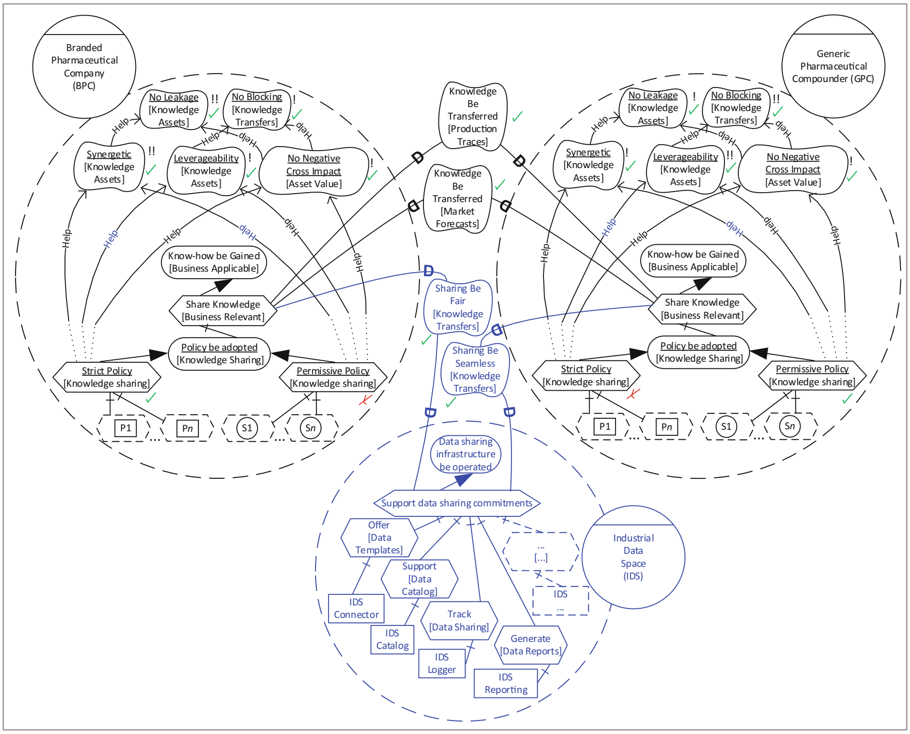
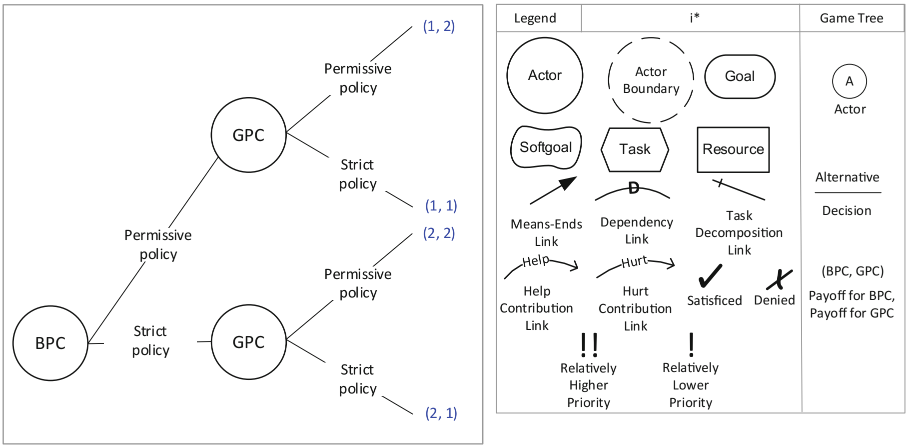


Fig. 4. Goal model of To-Be scenario representing knowledge sharing goals and potential tasks, synthesized from [21–26] – the To-Be scenario (Color figure online)



(i) *i** SR diagram showing strategic goals of the two coopeting *actors* and a mediating *actor*



(ii) Game Tree showing *payoffs* from possible moves by BPC followed by GPC moves

Fig. 5. To-Be scenario

options in the As-Is scenario. Following the process described in Fig. 1 shows that multiple win-win strategies can be created in an industrial collaboration scenario where none existed originally. A comparison of Figs. 2 and 3 with Figs. 4 and 5 highlights a primary benefit of using this approach to co-develop *i** SR diagrams with Game Trees. In Figs. 3 and 5, the Game Trees are structurally similar but have different *payoffs* and, in the *i** SR diagrams, the internal intentional structure of BPC and GPC is identical except for certain *contribution links*. Figures 2 and 4 are crucial for understanding the reasons for these differences. The goal models in Figs. 2 and 4 explain the reasons for the differences in the *payoffs* on the Game Trees and the changes in the *contribution links* within the *i** SR diagrams.

4 Related Work

This paper contributes to the body of knowledge pertaining to intentional modeling of coopetition. Majority of the research on coopetition modeling has focused on game-theoretic approaches [4]. Such approaches encode the intentionality of the *players* within the *payoffs* thereby eliding their goal structures. Recent research in the enterprise modeling literature has focused on the intentionality of actors engaged in strategic coopetition. Requirements for enterprise modeling of strategic coopetition are described in [4, 33]. The intentional modeling approach that is applied in this paper was introduced in [7] and refined in [32].

In [32] a basic example of cake-cutting is presented to demonstrate the application of this process. That example of cake-cutting is drawn from game theory and is used to demonstrate the co-design and co-evolution of *i** SR diagrams and their corresponding Game Trees. That example shows the introduction of a new alternative in an ultimatum game between two *players* to generate a new win-win strategy when originally none existed. That pathway to win-win is further illustrated with a case of coopetition between software ecosystems of Apple and Adobe. Modeling of complementarity, which is a motivator of coopetition, and relevant in knowledge-sharing scenarios, is discussed in [34]. More broadly, this research paper also contributes to the scholarly literature on enterprise modeling of business strategy. Researchers in this domain have developed modeling techniques that incorporate strategic management concepts [35–39].

5 Conclusions and Future Work

We utilized a strategic modeling approach to systematically search for win-win strategies and generate new alternatives for organizations under coopetition. This integrative approach incrementally and iteratively elaborated and refined the *i** SR diagram and its corresponding Game Tree. No win-win strategies were detected in the As-Is scenario due to threats related to knowledge leakage and knowledge blocking. However, in the To-Be scenario, multiple win-win strategies were generated by applying this strategic modeling approach to the As-Is scenario. New *softgoals* and *tasks* were added that obviated the threats from knowledge leakage and knowledge blocking. These *softgoals* and *tasks* could be satisfied by the *actors* by themselves (e.g., by building a system that meets necessary requirements) or with the help of another *actor* (e.g., by subscribing to a service that meets necessary requirements). In this paper we depicted the latter option.

This strategic modeling approach incorporates three practical and reasonable assumptions to ensure its usefulness in real-world applications [7]. However, the efficacy and viability of these assumptions needs to be tested via empirical investigation. Our future work will comprise achievement of three objectives that must be satisfied to encourage mainstream adoption of these models by industry professionals. Firstly, these models may need to be simplified to gain broader acceptance by practitioners. This would be done by developing collaboration patterns that represent common behaviors in the real world (e.g., collaborating to avoid common threat). Secondly, these models may need to support more sophisticated and nuanced methods for calculating payoffs. Game Theorists have proposed many methods for calculating payoffs under different circumstances and these methods could be supported by these models. Thirdly, these models may need to be commingled with existing processes that are used by organizations to manage coopetitive relationships. For example, organizations use contracts and legal agreements to set the terms and conditions of such relationships. These models could be used to support the contract negotiation and agreement formation processes. These areas of future work shall increase the value and utility of these models in the industry.

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