10

On the Trustee's Side:
Trust As Relational Capital

In most of the current approaches to trust, the focus of the analysis is on the trustor and on the ways to evaluate the trustworthiness of possible trustees. In fact, there are not many studies and analyses about the model of *being trusted*. But trust can be viewed at the same time as an instrument both *for an agent selecting the right partners in order to achieve its own goals* (the trustor's point of view), and *for an agent to be selected from other potential partners* (the point of view of the trustee) in order to establish a cooperation/collaboration with them and to take advantage of the accumulated trust. In the other chapters of this book we have focused our attention on the first point of view.

In this chapter[1] we will analyze trust as the agents' *relational capital*. Starting from the classical dependence network (in which *needs*, *goals*, *abilities* and *resources* are distributed among the agents) with potential partners, we introduce the analysis of what it means for an agent to be trusted and how this condition could be strategically used by him to achieve his own goals, that is, why it represents a form of power.

The idea of taking the trustee's point of view is especially important if we consider the amount of studies in social science that connect trust with *social capital* related issues. Our socio-cognitive model of trust (see previous chapters) is about the cognitive ingredients for trusting something or somebody, and how trust affects decisions, which are the sources and the basis for trusting, and so on; we do not model what it means to be trusted (with the exception of the work on trust dynamics (Chapter 6) in which the focus is also on the reciprocation and potential influences on the trustworthiness) and why it is important.

Here we address this point, analyzing what it means for trust to represent a strategic resource for agents who are trusted, proposing a model of '*trust as a capital*' for individuals.

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[1] We thank Francesca Marzo for her precious contribution on the first reflections on this topic.

Our thesis is that *to be trusted*:

i) *Increases* the chance of being requested or accepted as a partner for exchange or coop-
eration.
ii) *Improves* the 'price', the contract that the trustee can obtain.

The reason for this new point of view derives directly from the fact that in human societies
as well as in multi-agent systems it is strategically important not only to know who is trusted
by whom and how much, but also to understand how being trusted can be used by several
potential trustors. It has already been shown in the previous chapters that using different
levels of trust represents an advantage when performing some tasks, such as allocating a task
or choosing between partners. Therefore, having 'trust' as a cognitive parameter in agents'
decision making can lead to better (more efficient, faster etc.) solutions than proceeding when
driven by other kinds of calculation such as probabilistic or statistical ones. This study has
already represented an innovation since trust has usually been studied as an effect rather than
a factor that causes the development of a social network and its maintenance or structural
changes.

In order to improve this approach and to understand dynamics of social networks better,
we now propose a study of what happens on the other side of the two-way trust relationship,
focusing on the trustee, in particular on a *cognitive trustee*. Our aim is an analytical study of
what to be trusted means. In our view:

- To be trustworthy usually is an advantage for the trustee (agent *Y*); more precisely, received
  trust is a capital that can be invested, even if it requires choices and costs to be cumulated.
- It is possible to measure this capital, which is relational, that is depends on a position in a
  network of relationships.
- Trust has different sources: from personal experience that the other agents have had with
  Y; from circulating reputation of *Y*; from *Y*'s belongingness to certain groups or categories;
  from the signs and the impressions that *Y* is able to produce.
- The value of this capital is context dependent (and market dependent) and dynamic.
- Received trust strongly affects the 'negotiation power' of *Y* that cannot simply be derived
  from the 'dependence bilateral relationships'.

Although there is a big interest in literature about 'social capital' and its powerful effects on
the well being of both societies and individuals, often it is not clear enough what the object
is that's under analysis. Individual trust capital (*relational capital*) and collective trust capital
not only should be disentangled, but their relations are quite complicated and even conflicting.
To overcome this gap, we propose a study that first attempts to understand what trust is as the
competitive capital of individuals. How is it possible to say that 'trust' is a capital? How is this
capital built, managed and saved? Then we aim to study the cognitive dynamics of this object
analytically, with a particular focus on how they depend on beliefs and goals.

10.1   Trust and Relational Capital

Social capital ((Coleman, 1988), (Bourdieu, 1983), (Putnam, 1993), (Putnam, 2000),) can be
seen as a multidimensional concept and can be studied in its relation both to social norms

and shared values and to networks of interpersonal relations. While in the former case studies about conventions and collective attribution of meanings it was useful to study how social capital can be a capital for society, in the latter, one of the basic issues that needs to be studied is how it can happen that networks of relations can be built, how they develop, and how they can both influence individual behaviours and be considered as an individual capital.

We also would like to reiterate that social capital is an ambiguous concept. By 'social', a lot of scholars in fact mean 'collective', some richness, an advantage for the collective; something that favors cooperation, and so on. On the contrary, we assume here (as a first step) an individualistic perspective, considering the advantages of the trusted agent (deriving from his relationships with other agents), not the advantages for the collective, and distinguishing between 'relational capital' (Granovetter, 1973) and the more ambiguous and extended notion of 'social capital'. The individual (or organization) Y could use his capital of trust, for non-social or even anti-social purposes.

In economic literature the term 'capital' refers to a commodity itself used in the production of other goods and services: it is, then, seen as a man-made input created to permit increased production in the future. The adjective 'social' is instead used to claim that a particular capital not only exists in social relationships but also consists in some kind of relationship between economical subjects. It is clear that for the capital goods metaphor to be useful, the transformative ability of social relationships to become a capital must be taken seriously. This means that *we need to find out what is the competitive advantage not simply of being part of a network, but more precisely of being trusted in that network.*

In the other chapters in this book, the additional value of trusting is shown to be as a crucial argument in decision making and in particular in the choice of relying on somebody else for achieving specific goals included in the plans of the agents. Trust is analyzed as a valuation of the other and the expectations of him, and it is shown how these characteristics and mechanisms, being part of the decision process at the cognitive level, represent an advantage for society in terms of realizing cooperation among its actors and for the trustor in terms of efficiency of choices of delegation and reliance (Castelfranchi and Falcone, 1998).

Changing the point of view, we now want to focus on the trusted agent (the trustee). However, to account for this it is necessary to rethink the whole theory of negotiation power based on dependence ((Castelfranchi and Conte, 1996), (Sichman *et al.*, 1994), (Castelfranchi *et al.*, 1992), (Conte and Castelfranchi, 1996)).

Trying to build a theory of dependence including trust does not mean basing the theory of social capital on dependence, but to admit that the existing theory of dependence network and the consequent theory of social power is not enough without the consideration of trust. What we need, then, is a comprehensive theory of trust from the point of view of the trusted agent, in order to find out the elements that, once added to the theory of dependence, can explain the *individual social power in a network*, on the one hand, and, only in a second phase, the *social capital meant as a capital for the society*.[2]

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[2] The advantage for a given community, group, organization or society of a diffuse trust atmosphere, of reciprocal trust attitudes and links in the social network, where (ideally) everybody trusts everybody (see Chapter 6), and trust is not monopolized by a few individuals who take advantage of that to seize negotiation power. This 'collective' meaning is mainly focused on the (quite confused) notion of 'trust capital', see http://www.socialcapitalgateway.org/eng-finland2007.html

Once a quantitative notion of the value of a given agent is formulated by calculating *how much the agent is valued by other agents in a given market for (in realizing) a given task*, we can say that this trust-dependent value is a real capital. It consists of all the relationships that are possible for the agent in a given market and, together with the possible relationships in other markets, it is the so-called *relational capital* of that agent. It differs from simple relationships in given networks, which are a bigger set, since it only consists of relationships the agent has with those who not only need him but have a good attitude toward him and, therefore, who are willing to have him as a partner. How much is he appreciated and requested? How many potential partners depend on Y and would search for Y as a partner? How many partners would be at Y's disposal for proposals of partnership, and what 'negotiation power' would Y have with them?

These relationships form a capital because (as with any other capital) it is the result of investments and it is costly cumulated it.

In a certain sense it represents a strategic tool to be competitive, and, also, as happens with other capitals such as the financial one, it is sometimes even more important that the good which is sold (be it either a service or a material good). For example, when Y decides to not keep a promise to X, he knows that X's trust in Y will decrease: is this convenient for future relationships with X? Will Y need to count on X in the future? Or, is this move convenient for reputation and other relationships?

For this reason it is very important to study how it is possible for the agent to cumulate this capital without deteriorating or wasting it: since the relational capital can make the agent win the competition even when the goods he offers is not the best compared with substitutive goods offered in the market. It should be shown quantitatively what this means and what kind of dynamic relationships exist between quality of offered good and relational capital.

10.2 Cognitive Model of Being Trusted

Before considering trust from this new perspective, let us underline a very important point, which will be useful for this work. The theory of trust and the theory of dependence are not independent from each other. Not only because – as we modelled ((Castelfranchi and Falcone, 1998), (Falcone and Castelfranchi, 2001)) before deciding to actively trust somebody, to rely on him (Y), one (X) has to be dependent on Y: X needs an action or a resource of Y (at least X has to believe so). But also because *objective* dependence relationships (Castelfranchi and Conte, 1996), that are the basis of adaptive social interactions, are not enough for predicting them. *Subjective* dependence is needed (that is, the dependence relationships that the agents know or at least believe), but is not sufficient; it is also necessary to add two relevant beliefs:

 (i) the belief of being dependent, of needing the other;
(ii) the belief of the trustworthiness of the other, of the possibility of counting upon him.

If X does not feel dependent on Y, she could not rely on him.

It is important to remind ourselves (see Section 2.3) of a crucial clarification. *X is (and feels) dependent on Y even if/when she is able to achieve her goal g, and to perform the (or an) appropriate action.* X can trust Y and delegate and rely on him even when she has the alternative of 'doing it myself'. This is what one might call 'weak dependence': I would be
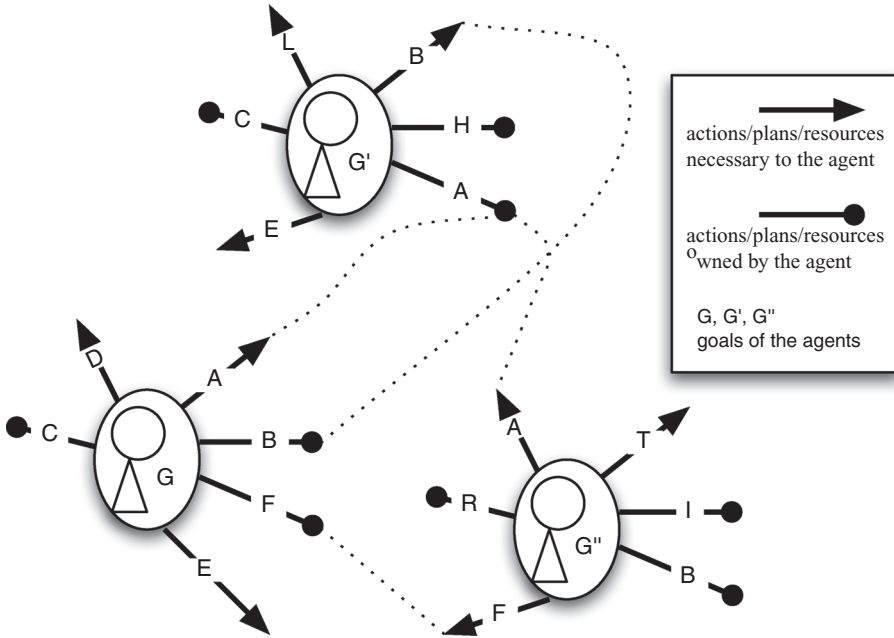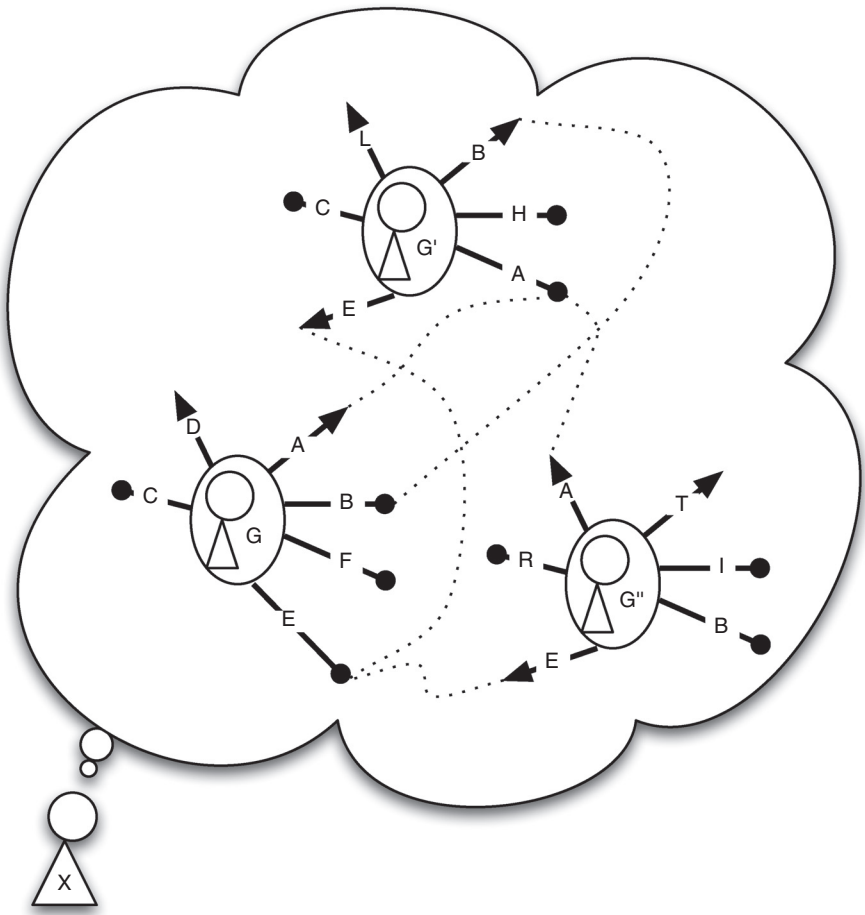
Figure 10.1   Objective dependence network

able to do the needed action myself. However, as we have explained 'weak dependence' is still 'dependence'. In fact, if *X* prefers and chooses to delegate to *Y*, this *necessarily* means that *X* sees some advantage, some convenience; that is: she not only achieves *p* – through *Y*'s action – but also achieves some additional goal (say *q*; for example, a better quality, less costs or effort, etc.). Thus, necessarily the reliance is about realizing *p+q*, and relatively to this real global goal of *X* and of the delegated action, *X* is just and fully dependent on *Y*.

10.2.1   Objective and Subjective Dependence

The theory of dependence includes in fact two types of dependence:

(1) The *objective dependence*, which says who needs whom for what in a given society (although perhaps it also ignores this). This dependence already has the power to establish certain asymmetric relationships in a potential market, and it determines the actual success or failure of the reliance and transaction (see Figure 10.1).

(2) The *subjective (believed) dependence*, which says who is believed to be needed by who. This dependence is what determines relationships in a real market and settles on the negotiation power; but it might be illusory and wrong, and one might rely upon unsuitable agents, even if one could actually do the action oneself. For example, in Figures 10.2A and 10.2B the dependence relationships as believed by *X* and *Y* respectively are shown: they are different from the objective dependence shown in Figure 10.1, but in fact it is on these beliefs that the agents make decisions.
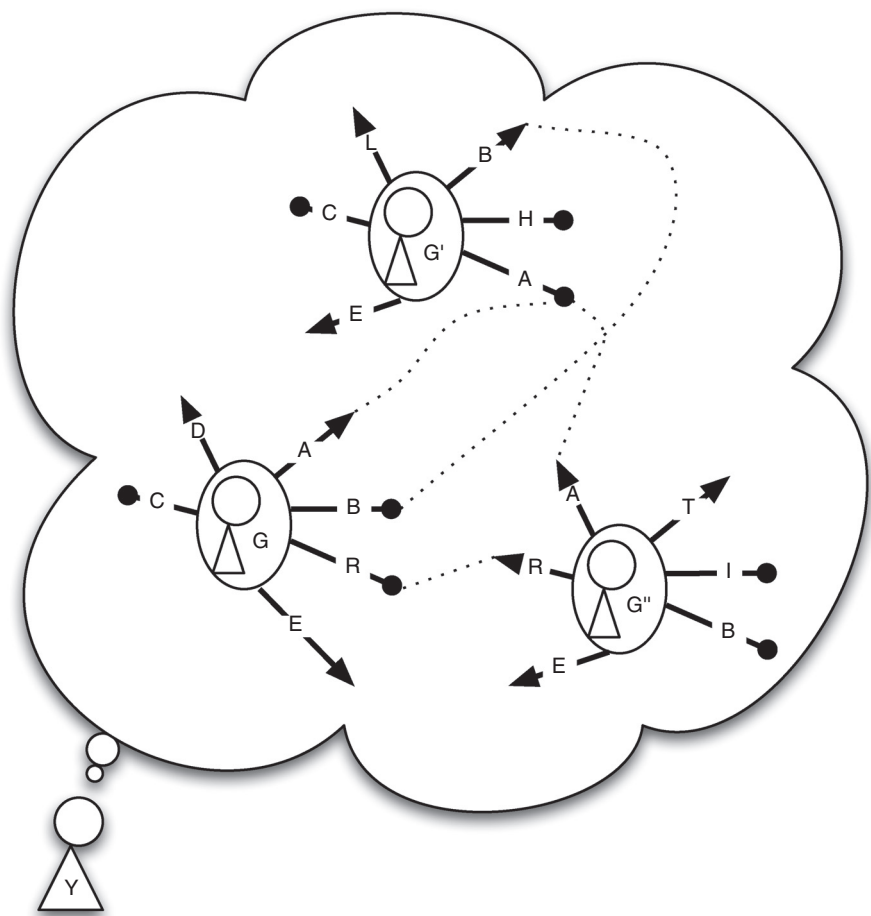
Figure 10.2A   Subjective dependence network (believed by *X*)

More formally, let $Agt = \{Ag_1,.., Ag_n\}$ a set of *agents*; we can associate to each agent $Ag_i \in Agt$:

- a set of *goals* $G_i = \{g_{i1},..,g_{iq}\}$;
- a set of *actions* $Az_i = \{\alpha_{i1},.., \alpha_{iz}\}$; these are the elementary actions that Ag_i is able to perform;
- a set of *plans* $\Pi = \{p_{i1},..,p_{is}\}$; Ag_i's plan library: the set of rules/prescriptions for aggregating the actions; and
- a set of *resources* $R_i = \{r_{i1},..,r_{im}\}$.

Each goal needs a set of actions/plans/resources.

Then, we can define the *dependence relationship* between two agents (Ag_j and Ag_i) with respect to a goal g_{jk}, as *Obj-Dependence (Ag_j, Ag_i, g_{jk})* and say that: *An agent Ag_j has an Objective Dependence Relationship with agent Ag_i with respect to a goal g_{jk} if there are*

Figure 10.2B Subjective dependence network (believed by *Y*)

necessary actions, plans and/or resources that are owned by Ag_i and not owned by Ag_j.in order to achieve g_jk.

In general, Ag_j has an Objective Dependence Relationship with Ag_i if in order to achieve at least one of its goals $g_{jk} \in G_j$, there are necessary actions, plans and/or resources that are owned by Ag_i and not owned by Ag_j (or, that is the same, they are owned by Ag_j but not usable by it for several reasons).

Ag_j has not got the 'power of' achieving g_{jk}, while Ag_i has this 'power of'.

As in (Castelfranchi *et al.*, 1992) we can introduce the *unilateral*, *reciprocal*, *mutual* and *indirect* dependence (see Figure 10.3). In very short and simplified terms, we can say that the difference between reciprocal and mutual is that the first is on different goals while the second is on the same goal.
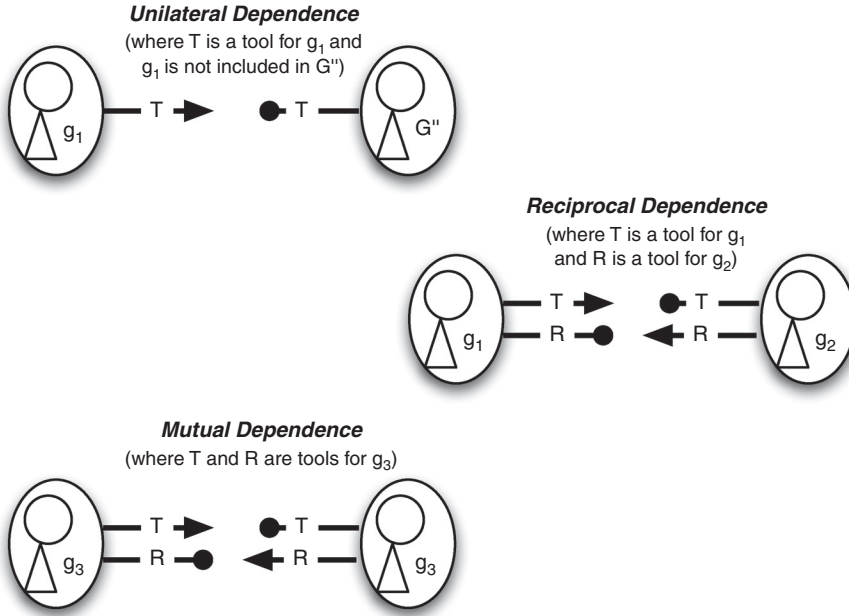
Figure 10.3   Unilateral, Reciprocal and Mutual Dependence

If the world knowledge were perfect for all the agents, the above described objective dependence would be a common belief about the real state of the world (Figure 10.1). In fact, the important relationship is the network of dependence *believed by each agent* (see Figures 10.2A and 10.2B). In other words, we cannot only *associate* a set of goals, actions, plans and resources with each agent, but we have to evaluate these sets as believed by each agent (the subjective point of view) and also take into consideration that they would be partial, different from each other, sometimes wrong, and so on. In more practical terms, each agent will have a different (subjective) representation of the dependence network as exemplified in Figures 10.1, 10.2A, and 10.2B.

For this reason we introduce the formula $Bel_k G_z$ that represents Ag_z's goal set as believed by Ag_k. The same for $Bel_k Az_z$, $Bel_k \Pi_z$, and $Bel_k R_z$, respectively, for actions, plans and resources. In practice, the dependence relationships should be re-modulated on the basis of the agents' subjective interpretation. The really operative part of the resulting interactions among the agents is due to their beliefs about the reciprocal dependences rather than the objective dependences; although, the final results of those interactions are also due to the 'objective' powers and dependence relations, even if ignored by the agents.

We call *Subj-Dependence(Ag_j, Ag_i, g_{jk})* when representing Ag_j's point of view with respect its dependence relationships with Ag_i about its k-th goal g_{jk}. Analogously, we call *Obj-Dependence(Ag_j, Ag_i, g_{jk})* for representing the objective dependence relationship of Ag_j with Ag_i about its k-th goal g_{jk}. In the first place, each agent should correctly believe what is true of their own goals, actions, plans, resources; while they could mismatch the sets of other agents.

We define *Dependence-Network(Agt,t)* the set of dependence relationships (both subjective and objective) among the agents included in *Agt* set at the time *t*. Each agent $Ag_j \in Agt$ must have at least one dependence relation with another agent in *Agt*.

More formally, a dependence network of a set of agents *Agt* at the time *t* can be written:

$$Dependence\text{-}Network(Agt, t) = Obj\text{-}Dependence(Ag_j, Ag_i, g_{jk}) \qquad (10.1)$$
$$\cup \ \text{Subj-}Dependence(Ag_j, Ag_i \ g_{jk})$$

with $Ag_j, Ag_j \in Agt$.

10.2.2 Dependence and Negotiation Power

Given a *Dependence-Network(Agt,t)*, we define

Objective Potential for Negotiation of $Ag_j \in Agt$ about its own goal g_{jk} – and call it *OPN(Ag_j, g_{jk})* – the following function:

$$OPN(Ag_j, g_{jk}) = f \left(\sum_{i=1}^{l} \frac{1}{1 + p_{ki}} \right) \qquad (10.2)$$

Where:

- f is in general a function that preserves monotonicity (we will omit this kind of function in the next formulas);
- l represents the number of agents in the set *Agt* that have an objective dependence relation with Ag_j with respect to g_{jk} (this dependence relation should be either reciprocal or mutual: in other words, there should also be an action, plan, or resource owned by Ag_j that is necessary for the satisfaction of any of Ag_i's goals);
- p_{ki} is the number of agents in *Agt* that are objectively requiring (there is an analogous dependence relation) the same actions/plans/resources (as useful for g_{jk}) to Ag_i on which is based the dependence relation between Ag_j and Ag_i and that in consequence are competitors with Ag_j actions/plans/resources in an incompatible way (Ag_i is not able to satisfy all the agents at the same time: there is a saturation effect). See Figure 10.4 for an example.

So, in case there are no competitors with Ag_j ($p_{ki}=0$ for each $i \in \{1,\ldots, l\}$) we have:

$$OPN(Ag_j, g_{jk}) = f \left(\sum_{i=1}^{l} \frac{1}{1 + p_{ki}} \right) = l \qquad (10.3)$$

More precisely, this *Objective Potential for Negotiation* should be normalized and evaluated with respect to each of the potential required tasks (actions, plans, resources) for the goal in object (g_{jk}): in fact, the achievement of this goal could require different performances of the dependent agents (see, for example, Figure 10.5: Ag_j needs A, B and C to achieve its goal g_{jk}). In the dependence network there are three agents. Ag_1 can offer A and B and can exploit N by Ag_j; Ag_2 can offer A and C and can exploit L by Ag_j; Ag_3 can offer B and can exploit N by Ag_j. Finally, Ag_2 is concurrent with Ag_j on B with both Ag_1 and Ag_3 (see also Figure 10.4).
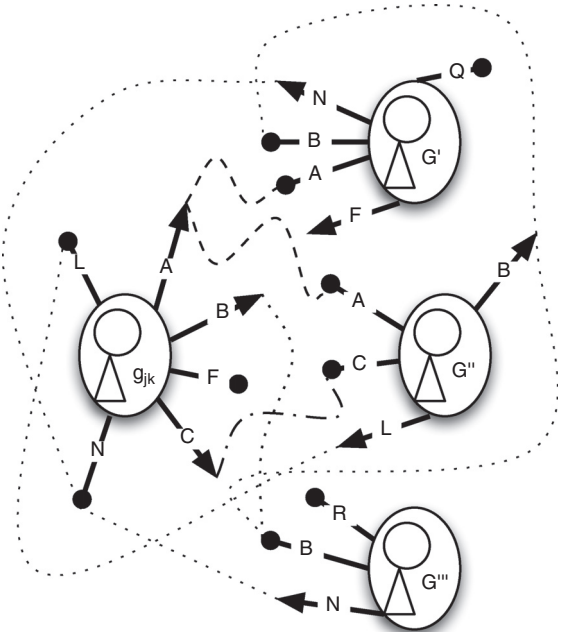
Figure 10.4 Ag_j Ag_2 and Ag_3 as competitors on a resource owned by Ag_1
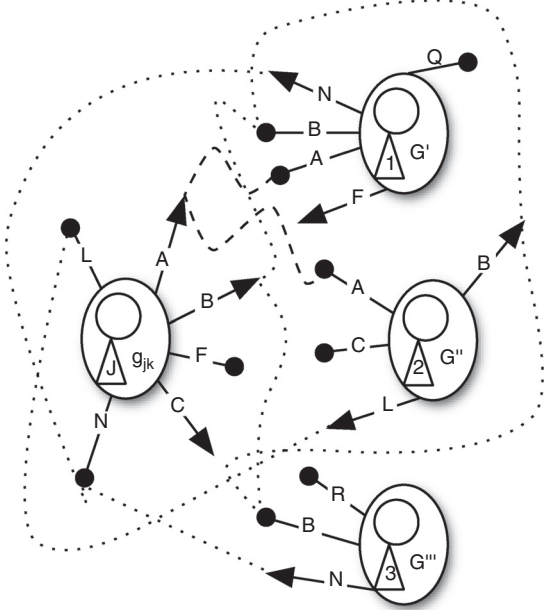
Figure 10.5   Example of *Objective Potential for Negotiation*
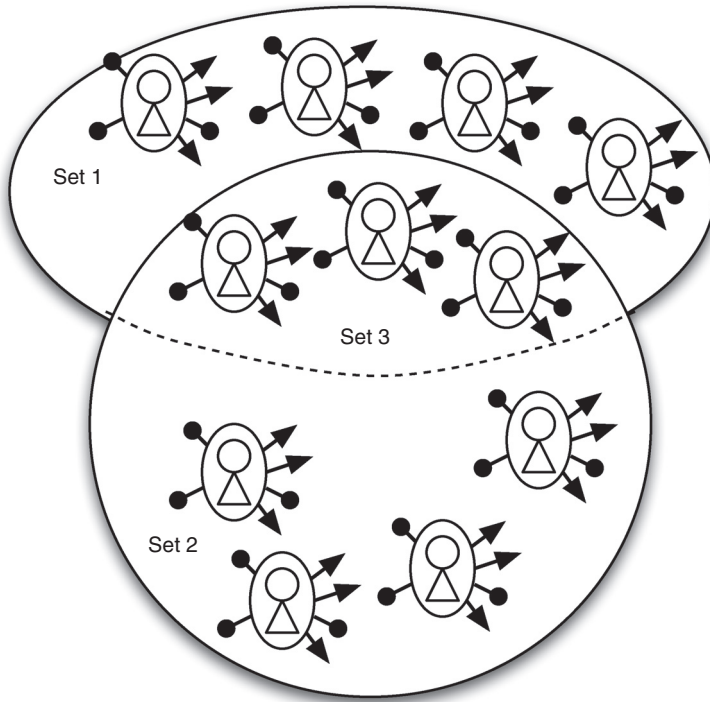
Figure 10.6 Matching the agents who depend on Ag_j for something and those on which Ag_j depends for its goal g

In general, we can represent the objective dependence of Ag_j as shown in Figure 10.6: *set1* represents the set of agents who depend on Ag_j for something (actions, plans, resources), *set2* represents the set of agents on which Ag_j depends for achieving their own specific goal g_{jk}. The intersection between *set1* and *set2* (part *set3*) is the set of agents with whom Ag_j could potentially negotiate for achieving g_{jk}. The greater the overlap the greater the *negotiation power* of Ag_j in that context.[3]

However, the negotiation power of Ag_j also depends on the possible alternatives that its potential partners have: the fewer alternatives to Ag_j they have, the greater its negotiation power (see Figure 10.4). We can define the *Subjective Potential for Negotiation* of $Ag_j \in Agt$ about its own goal g_{jk} – and call it $SPN(Ag_j, g_{jk})$ – the following function:

$$SPN(Ag_j, g_{jk}) = \sum_{i=1}^{l^{Bj}} \frac{1}{1 + p_{ki}^{Bj}} \qquad (10.4)$$

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[3] Even if increasing the number of agents in the overlap doesn't necessarily increase the probability of achieving Ag_j's goal (maybe one (or more) of the needed resources is not owned by an increasing number of agents).

where the apex B_j means 'believed by Ag_j'; in fact in this new formula Ag_j both *believes* the number of potential collaborative agents (l) and the number of competitors (p_{ki}) for each of them.

It is clear how, on the basis of these parameters (l^{Bj} and $p_{ki}{}^{Bj}$), the negotiation power of Ag_j is determined. And, at the same time, his own decisions will be strongly influenced. Analogously, we can interpret Figure 10.5 as the set of relationships among the agents, believed by Ag_j. In this case we take the subjective point of view.

10.2.3   Trust Role in Dependence Networks

We would like to introduce into the dependence network the trust relationship. In fact, the dependence network alone is not sufficient for a real allocation of tasks among the agents. It is true that Ag_i should be able and willing to realize the action α_k: But how? And, will it be sufficient given my expectations? Would it be more or less trustworthy than Ag_z? To answer these questions the agents in the dependence network have to establish among themselves the reciprocal trust about the different tasks they can allocate to each other.

Indeed, *although it is important to consider the dependence relationship between agents in society, there will be not an exchange in the market if there is not the trust to strengthen these connections*. Considering the analogy with Figure 10.4, we will now look at a representation as given in Figure 10.7 (where *Set 4* includes the set of agents that Ag_j considers trustworthy for achieving g_{jk}).

We have now a new subset (the dark agents in Figure 10.7) containing the potential agents for negotiation. By introducing the basic beliefs about trust in the *Subjective Potential for Negotiation* (of $Ag_j \in Agt$ and its own goal g_{jk}) we also introduce the superscript index T to differentiate it from the *SPN* without trust and we have:

$$SPN^T(Ag_j, g_{jk}) = \sum_{i=1}^{l^{Bj}} \frac{DoA_{ik}{}^{Bj} * DoW_{ik}{}^{Bj}}{1 + p_{ki}{}^{Bj}}) \tag{10.5}$$

with $1 \geq DoA_{ik}{}^{Bj}, DoW_{ik}{}^{Bj} \geq 0$.

where $DoA_{ik}{}^{Bj}$ and $DoW_{ik}{}^{Bj}$ are, respectively, the degree of ability and willingness (with respect to the goal g_{jk}) of the agent Ag_i as believed by Ag_j (see Chapter 3). We do not consider here the potential relations between the values of $DoA_{ik}{}^{Bj}$ and $DoW_{ik}{}^{Bj}$ with the variable $p_{ki}{}^{Bj}$.

On analyzing Figure 10.7, we can see that there are two other agents (medium dark) that are trustworthy according to Ag_j on the goal g_{jk} but they do not depend on Ag_j for something. In fact the dependence and trust relationships are strongly interwined and not simply sequential as shown above. Not only does the decision to trust presuppose a belief of being dependent, but notice that a dependence belief (*BelDep*) implies on the other hand an element of trust. In fact to believe oneself to be dependent means:

- (*BelDep-1*) to believe not to be able to perform action α and to achieve goal g; and
- (*BelDep-2*) to believe that Ag_i is *able* and in condition to achieve g, performing α.

Notice that (*BelDep-2*) is precisely one component of trust in our analysis: the *positive evaluation* of Ag_i as competent, able, skilled, and so on. However, the other fundamental
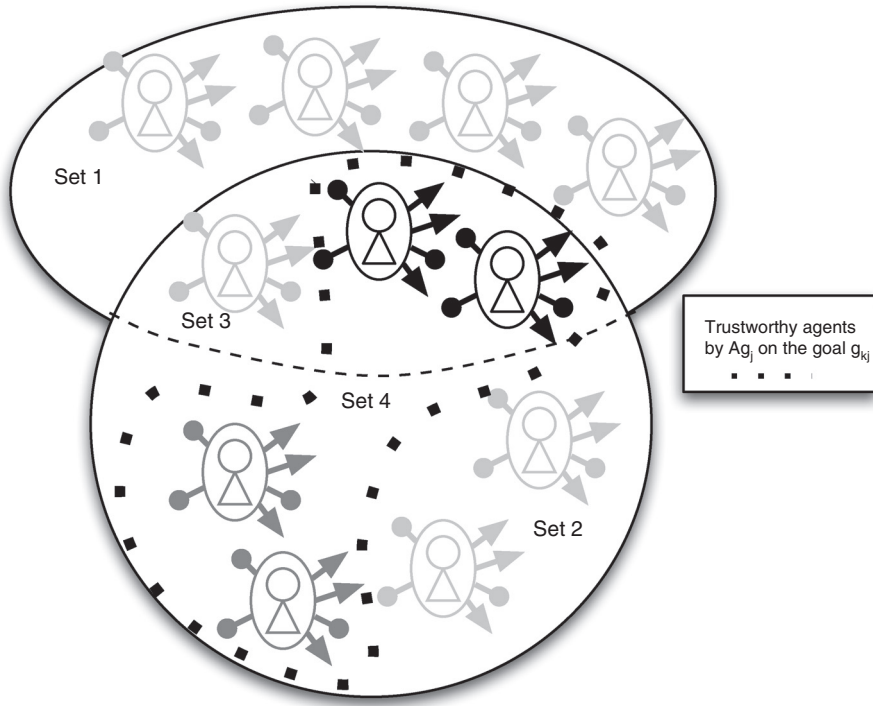
Figure 10.7 Subset of Agents selected by introducing also the trustworthiness of the agents (in Ag_j's point of view) in the dependence network

component of trust as evaluation is lacking: reliability, trustworthiness: Ag_i really intends to do, is persistent, is loyal, is benevolent, etc. Thus he will really do what Ag_j needs.

Given the basic role played by 'believed networks of dependence', established by a believed relationship of dependence based on a belief of dependence, and given that this latter is one of the basic ingredients of trust as a mental object, we can claim that this overlap between theories is the crucial issue and our aim is namely to study it in great depth.

Analogously, but less relevant in this case, we can introduce the *Objective Potential for Negotiation* (of $Ag_j \in Agt$ about its own goal g_{jk}), we have:

$$OPN^T(Ag_j, g_{jk}) = \sum_{i=1}^{l} \frac{DoA_{ik} * DoW_{ik}}{1 + p_{ki}} \tag{10.6}$$

where DoA_{ik} and DoW_{ik} respectively represent *objective* Ag_i's ability and willingness to use actions/plans/resources for the goal g_{jk}.

When a cognitive agent trusts another cognitive agent, we talk about social trust. We consider here the set of actions, plans and resources owned/available by an agent that can be useful in achieving a set of tasks $(\tau_1, \ldots, \tau_r)$.

We *now take the point of view of the trustee in the dependence network*: so we present a cognitive theory of trust as a capital. That is to say that if somebody is (potentially) strongly useful to other agents, but is not trusted, its negotiation power is not high.

As showed in Chapter 3 we call *Degree of Trust* of the agent Ag_j for the agent Ag_i about the task τ_k ($DoT(Ag_j\ Ag_i\ \tau_k)$):

$$DoT(Ag_j, Ag_i, \tau_k)^{Bj} = DoA_{ik}^{Bj} * DoW_{ik}^{Bj} \tag{10.7}$$

In the same way we can also define the *self-trust* of the agent Ag_i about the task τ_k:

$$ST(Ag_i, \tau_k) = DoA_{ik}^{Bi} * DoW_{ik}^{Bi} \tag{10.8}$$

We call the *Objective Trust Capital* of $Ag_i \in Agt$ about a potential delegable task τ_k the function:

$$OTC(Ag_i, \tau_k) = \sum_{j=1}^{l} DoA_{ik}^{Bj} * DoW_{ik}^{Bj} = \sum_{j=1}^{l} DoT(Ag_j, Ag_i, \tau_k)^{Bj} \tag{10.9}$$

Where l is the number of agents (included in the dependence network) who need to delegate the task τ_k. Note that we are calling as objective trust capital the sum of the trustworthiness that the other agents in the *DN* attribute to Ag_i rather than the capital Ag_i could deserve on the basis of his own objective relationships: in other words, *it is referred to the partial (subjective) points of view of the other agents.*

In words, the cumulated trust capital of an agent Ag_i with respect to a specific delegable task τ_k, is the sum (all the agents need that specific task in the network dependence) of the corresponding abilities and willingness believed by each potentially dependent agent.[4]

We call the *Subjective Trust Capital* of $Ag_i \in Agt$ for a potential delegable task τ_k the function:

$$STC(Ag_i, \tau_k) = \sum_{j=1}^{l^{Bi}} DoA_{ik}^{BiBj} * DoW_{ik}^{\ BiBj} = \sum_{j=1}^{l^{Bi}} DoT(Ag_j, Ag_i, \tau_k)^{BiBj} \tag{10.10}$$

Where the apex B_iB_j means 'as Ag_i believes is believed by Ag_j'. Subjectivity means that both the network dependence and the believed abilities and willingness are believed by (the point of view of) the agent Ag_i. The subjectivity consists in the fact that both the network dependence and the believed abilities and willingness are believed by (the point of view of) the agent Ag_i (see Figure 10.8A and 10.8B).

Starting from Trust Capital we would like to evaluate its *usable part*. In this sense, we introduce the *Subjective Usable Trust Capital* of $Ag_i \in Agt$ for a potential delegable task τ_k as:

$$SUTC(Ag_i, \tau_k) = \sum_{j=1}^{l^{Bi}} \frac{DoT(Ag_j, Ag_i, \tau_k)^{BiBj}}{1 + p_{kj}^{\ Bi}} \tag{10.11}$$

Where the apex B_iB_j means 'what Ag_i believes is believed by Ag_j' and where $p_{kj}^{\ Bi}$ is (following Ag_i's belief about the beliefs of Ag_j) the number of other agents in the dependence network

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[4] We might consider in an even more objective way the capital based on the real trustworthiness of Ag_i (with respect to the task) rather than based on the $DoT(Ag_j\ Ag_i\ \tau_k)$ of the various agents Ag_j. But the trust capital is not interesting if it is not in the mind of the potential 'users'.
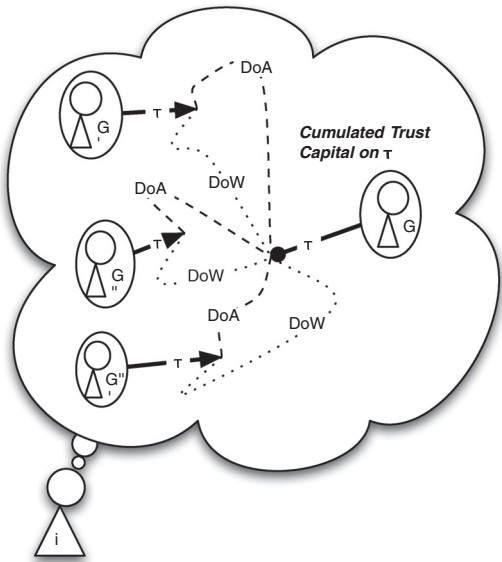
Figure 10.8A *Ag_I* believes the specific dependence network in which he has a cumulated Trust Capital (about a specific task)
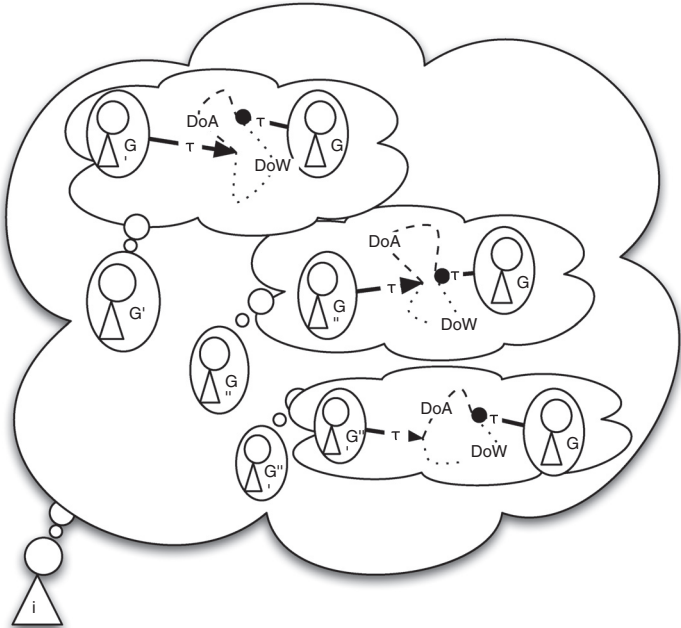
Figure 10.8B *Ag_I* believes how other agents evaluate his own abilities and willingness about a specific task
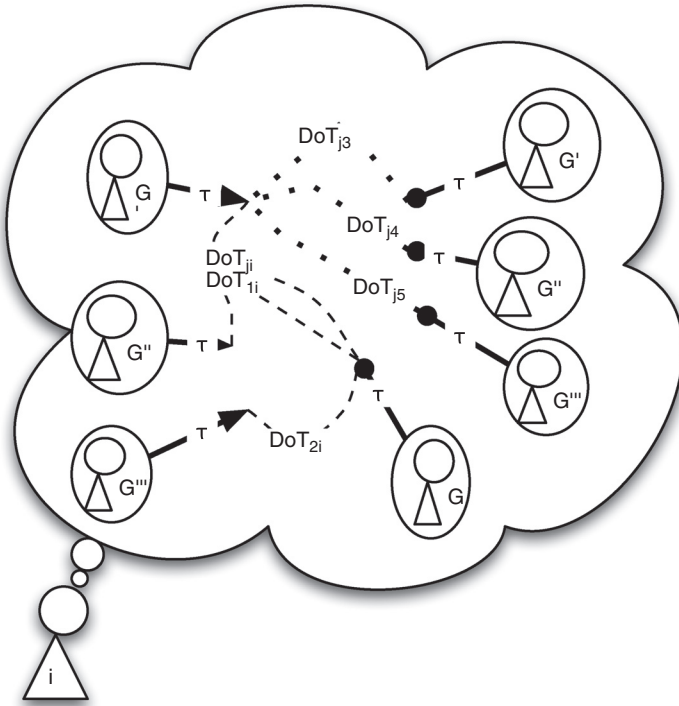
Figure 10.9 Example of positive (Ag_j, Ag_1, Ag_2) and negative (Ag_3, Ag_4, Ag_5) contributors to Ag_i's capital of trust (in Ag_i's mind)

that can realize and achieve the same task (with a trust value comparable with the one of Ag_i) to whom Ag_j can delegate the task τ_k (see Figure 10.9).

We say that there are two *comparable trust values* when the difference between them is in a range under a given threshold that could be considered meaningless with respect to the achievement of the task.

In Figure 10.9, Ag_1 and Ag_2 strengthen the trust capital of Ag_i (they are competitors with Ag_j about the task τ); while Ag_3, Ag_4 and Ag_5 weaken the trust capital of Ag_i because they are competitors with Ag_i in offering (at the same trustworthy value) the task τ. As shown in Figure 10.9, it is possible that Ag_i believes in potential competitors (jeopardizing his trust capital), but they are not really competitors because there are no links with his potential clients/ delegating (see Ag_3, Ag_4 and Ag_5 that are not linked with Ag_1 and Ag_2 but only with Ag_j).

Of course, we can analogously introduce the *Objective Usable Trust Capital* of $Ag_i \in Agt$ about a potential delegable task τ_k as:

$$OUTC(Ag_i, \tau_k) = \sum_{j=1}^{l} \frac{DoT(Ag_j, Ag_i, \tau_k)}{1 + p_{kj}} \tag{10.12}$$

In this paragraph we have introduced in the dependence network (that establishes, objectively or subjectively, how each agent can potentially depend on other agents to solve its own tasks) the trust relationships (that introduce an additional dimension, again evaluated both objectively and subjectively, in a potential partner selection for achieving tasks). In general, we can say that the introduction of trust relationships reduces the set of potential partners for each agent and for each task, with respect to the situation with the dependence relationships alone: more formally $OPN>OPN^T$, and $SPN>SPN^T$. Even if exceptions are possible: may be an agent trusts other agents on a specific task with respect to whom he really depends on.

From the comparison between $OUTC(Ag_i,\tau_k)$, $SUTC(Ag_i,\tau_k)$, $OTC(Ag_i,\tau_k)$, $STC(Ag_i,\tau_k)$, and $ST(Ag_i,\tau_k)$ a set of interesting actions and decisions are taken from the agents (we will see in the next paragraph).

10.3 Dynamics of Relational Capital

What has not been considered enough in organization theory is the fact that the *relational capital* is peculiar in its being crucially based on beliefs: again, what makes relationships become a capital is not simply the structure of the networks (who 'sees' whom and how clearly) but the evaluations and the levels of trust which characterize the links in the networks (who trusts whom and how much). Since trust is based on beliefs – including, as we said, the believed dependence (who needs whom) – it should be clear that *relational capital is a form of capital, which can be manipulated by manipulating beliefs.*

Thanks to a structural theory of what kind of beliefs are involved, it is possible not only to answer some very important questions about agents' power in networks, but also to understand the dynamical aspects of relational capital. In addition, it is possible to study what a difference between trustee's beliefs and others' expectations of him implies in terms of both reactive and strategic actions performed by the trustee.

10.3.1 Increasing, Decreasing and Transferring

As far as the dynamic aspects of this kind of capital are concerned, it is possible to make hypotheses on how it can increase or how it can be wasted, depending on how each of the basic beliefs involved in trust might be manipulated. In general, starting from the analysis of the previous paragraph, we can see how matching the different terms we have different interesting situations.

First of all, even if $OTC(Ag_i,\tau_k)$ is a relevant factor for the agent Ag_i (it shows in absolute terms how the trustworthiness of Ag_i is recognized), in fact the really important thing for an agent cumulating trust capital is $OUTC(Ag_i,\tau_k)$ that indicates not only the trustworthiness cumulated in the dependent agents, but also the number of possible other concurrent agents on that offered task. So, for example, it may be more important to have competence on tasks which are not highly required, but with a low number of concurrents, than viceversa.

Again it is interesting to consider the $SUTC(Ag_i,\tau_k)$ factor (in which a relevant role is played by the beliefs of the involved trustee) and its relationships with $OUTC(Ag_i,\tau_k)$, $SPN^T(Ag_j,g_{jk})$, and $OPN^T(Ag_j,g_{jk})$ factors. As we have seen in the previous paragraph, these factors are constituted by the beliefs of trustee or trustor, so it can be interesting to analyze the different situations matching them and evaluating the consequences of their coherence or incoherence.

A general rule (that could be easily translated into an algorithm) regards the fact that the trust capital of an agent (say Ag_i) increases when:

- the number of other trusted agents (competitors) in the DN offering the solution to the given task (or classes of tasks) decreases; and/or
- the number of agents (delegators/clients) in the DN requiring the solution to the given task (or classes of tasks) increases.

Following this analysis, the trustee should work to decrease the number of competitors (for example, disconnecting the links in the network, reducing their reputation, and so on) and/or he should work to increase the delegators (for example, connecting new ones, changing the needs of the connected ones, and so on).

Let us consider what kind of strategies can be performed to enforce the other's dependence beliefs and his beliefs about *agent's competence*. If Ag_i is the potential trustee (the collector of the trust capital) and Ag_j is the potential trustor we can say:

i) Ag_i can make Ag_j dependent on him by making Ag_j lack some resource or skill (or at least inducing Ag_j to *believe* so). He has to work on $SPN^T(Ag_j, g_{jk})$.

ii) Ag_i can make Ag_j dependent on him by activating or inducing in them a given goal (need, desire) in which Ag_j is not autonomous (Castelfranchi and Falcone, 2003) but is dependent on Ag_i (or in any case they believe so). In this case they have to find a way to include in G_j an additional g_{jk} such that Ag_j is dependent on Ag_i for that goal (and they believe that).

iii) Since dependence beliefs are strictly related to the possibility of others (for example Ag_j) being able to see the agent (for example Ag_i) in the network and to know their ability to perform useful tasks, the goal of the agent who wants to improve their own relational capital will be to *signal* their presence and their skills ((Schelling, 1960), (Spece, 1973), (Bird and Smith, 2005)). While to show his presence he might have to shift his position (either physically or figuratively, for instance, by changing his field), to communicate his skills he might have to hold and show something that can be used as a signal (such as an exhibition, certificate, social status, proved experience, and so on). This implies, in the plan of actions of the trustee, several necessary sub-goals to provide a signal. These sub-goals are costly to achieve and the cost the agent has to pay to achieve them has to prove the signals to be credible (of course without considering cheating by building signals). It is important to underline that using these signals often implies the participation of a third party in the process of building trust as a capital: a third party which must be trusted (Falcone and Castelfranchi, 2001). We would say the more the third part is trusted in society, the more expensive will it be for the agent to acquire signals to show, and the more successful these signals will be at increasing the agent's relational capital. Later we will see how this is related to the process of transferring trust from one agent to another (building reputation). Obviously Ag_i's *previous performances* are also 'signals' of trustworthiness. And this information is also provided by the circulating *reputation* of Ag_i ((Conte and Paolucci, 2002), (Jøsang and Ismail, 2002)).
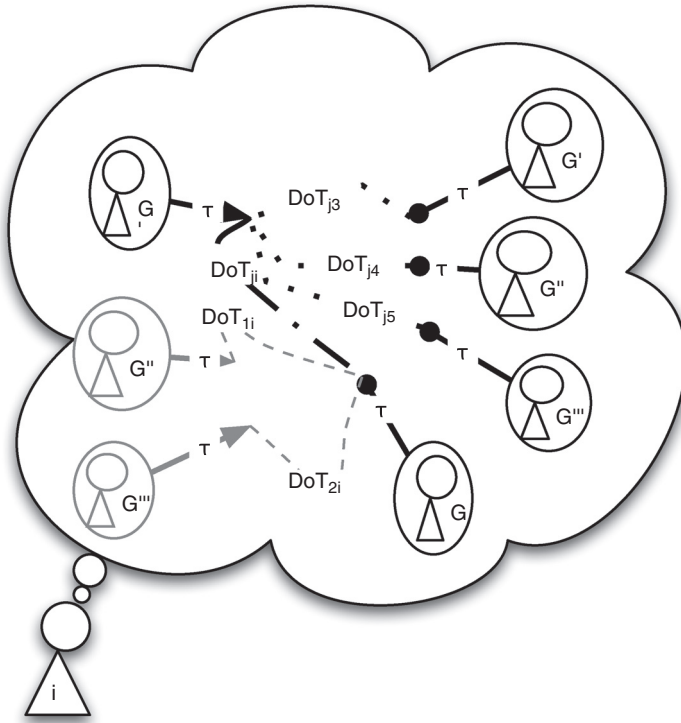
Figure 10.10 Example in which Ag_i might increase his own trust capital reducing in some way Ag_j's trust in his competitors (Ag_3, Ag_4, Ag_5)

iv) Alternatively, Ag_i could work to reduce the believed (by Ag_j) value of the ability of each of the possible competitors of Ag_i (in a number of p_{kj}) on that specific taskτ_k, See Figure 10.10: he has to work $SPN^T(Ag_j, g_{jk})$.

Let us now consider how *willingness beliefs* can be manipulated. In order to do so, consider the particular strategy that needs to be performed to gain the other's good attitude through gifts (Cialdini, 1990). It is true that the expected reaction will be of reciprocation, but this is not enough. While giving a gift Ag_i knows that Ag_j will be more inclined to reciprocate, but Ag_i also knows that his action can be interpreted as a sign of the good will he has: since he has given something without being asked, Ag_j is driven to believe that Ag_i will not cheat on her. Then, the real strategy can be played on trust, sometimes totally and sometimes only partially – this will basically depend on the specific roles of agents involved.

Again in formal terms, we can say that Ag_i has to work to increase his DoW_i as believed by Ag_j ($Bel_j(DoA_i)$).

Alternatively, it could work to reduce the believed (by Ag_j) value of willingness of each of the possible competitors of Ag_i (in number of p_{kj}) on that specific taskτ_k, See again Figure 10.10.

An important consideration we have to take is that a dependence network is mainly based on the set of actions, plans and resources owned by the agents and necessary for achieving the agents' goals (we considered a set of tasks each agent is able to achieve; its 'power of'). The interesting thing is that the dependence network is modified by the dynamics of the agents' goals: from their variations (as they evolve in time), from the emergency of new ones, from the disappearance of old ones, from the increasing request of a subset of them, and so on (Pollack, 1990). On this basis, the role of each agent in the dependence network changes, which in fact changes the trust capital of the involved agents.

Relational capital can also be circulated inside a given society. If somebody has a good reputation and is trusted by somebody else, they can be sure this reputation will be passed on and transfered to other agents – and this is always considered a good marketing strategy, word of mouth. What is not clear yet is how these phenomena work. But when trust in an agent circulates, it is strategically important for the agent to know how this happens and which paths (not only figuratively) trust follows.

In fact, not all the ways are the same: it is possible that being trusted by a particular agent could mean that he just has one more agent in his relational capital, but gaining the trust of another agent can be very useful to him and exponentially increase his capital thanks to the strategic role or position of this other agent. That said, the importance of understanding if and how much an agent is able to manage this potentiality of his capital should be clear.

Basically, here also, a crucial part is played by the involved agents: for this reason it is necessary for an agent to know *the multiplicative factors* represented by the recognized and trusted evaluator in society. It is not necessarily true, in fact, that when somebody trusts somebody else and they in turn trust a third one, the first one will trust the third one: the crucial question is 'which role does the first ascribe to the second'. If the second one is trusted as an evaluator by X, then X can trust the third one to achieve specific goals (see Chapter 6 for the analysis of the *trust transitivity*). Usually how well these transitive processes work depends on what kind of broadcasting and how many links the evaluator has and how much he is trusted in each of those links, so, basically, it depends on the evaluator's relational capital.

10.3.2 Strategic Behavior of the Trustee

Up until now we have just considered trust as something quantitatively changeable, but we did not talk about subjective difference in the way trust is perceived by the two parts of the relationship. Nevertheless, to be realistic, we must take into account the fact that there is often a difference between how the others actually trust an agent ($OTC(Ag_i, \tau_k)$) and what the agent believes about ($STC(Ag_i, \tau_k)$); but also between this and the level of trustworthiness that an agent perceives in themsel (we can refer to the $ST(Ag_i, \tau_k)$ factor for this). Since being able is not necessarily the reason for trust: it can be a diffuse atmosphere that makes the others trust the agent, although the agent doesn't possess all the characteristics required to be trusted.

In fact, these subjective aspects of trust are fundamental to the process of managing this capital, since it can be possible that the capital is there but the agent does not know how to reach it. Can it be possible to use the relational capital even if the person who uses it is not aware of having it?

At the basis of the possible discrepancy in the subjective assessment of trustworthiness there is the perception of how much an agent feels themselves to be trustworthy in a given task and the assessment that they do of how much the other agents trust them in the same task.

In addition, this perception can change and become closer to the objective level while the task is performed: the agent can either find out that they are being more or less trustworthy than they had believed, or realize that the others' perception was wrong (either positively or negatively). All these factors must be taken into account and studied together with the different components of trust, in order to build hypotheses on strategic actions that the agent can perform to cope with his relational capital.

We must consider what can be implied by these discrepancies in terms of strategic actions: how can they be individuated and valued? How will the trusted agent react when he becomes aware of that? He can either try to acquire competences in order to reduce the gap between others' valuation and his own, or exploit the existence of this discrepancy, taking economic advantage of the reputation over his capability and counting on the others' scarce ability to monitor and test his real skills.

10.4   From Trust Relational Capital to Reputational Capital

However, there is another 'evolutionary' step in this path from dependence and interpersonal trust relationships, to a personal, competitive 'relational capital' and the consequent 'negotiation power' and role in the 'market'. The 'relational capital' of the individual is not just the sum of the evaluations of the other members, and a simple interpersonal complex relation. This is just the basic, inter-personal layer. But the agents communicate about the features, the reliability, the trustworthiness of the others; and they not only communicate their own opinion, but they also report and spread around – without personal commitment – what they have heard about Y: Y's reputation

On such a basis a complex phenomenon emerges: Y's circulating reputation in that community; which is represented in nobody's mind in particular. However, this circulating phantom determines the individual perception of Y's reputation, then his trustworthiness in that community. In other words, beyond Y's ' trust-relational capital' there is an additional, emerging 'capital': Y's reputation. This capital in many contexts – in particular in open, anonymous 'markets', where individuals do not know each other – is the really fundamental one to determine Y's value in that market and his negotiation power.

This view of 'reputation' (rather close to Conte and Paolucci's theory-(Conte and Paolucci, 2002)) gives the right role to this important phenomenon and is less reductive than the view we have used before. We have (correctly, but in a rather reductive way) presented 'reputation' as one of the possible bases and sources of our evaluations and trust in Y. Apart from *personal experience* of X about Y, apart from *reasoning and instantiation from general categories*, *roles*, etc., apart from *various forms of 'transfer'* of trust, *reputation* (that is the circulating fame, voice, gossip about Y in a given community) can be the base of X 's opinion and trust in Y.

However, 'reputation' is not the single-agent 'opinion' about Y, or the communicated personal evaluation of Y: it is an emerging, anonymous phenomenon – to which nobody responds – which is self-organizing over the various implicit or explicit *messages* 'about' Y's virtues, competence and trustworthiness.

So, the relationship between trust and reputation is more dialectic: trust of community members in Y indirectly contributes to Y's reputation; and reputation contributes to their individual and diffuse trust in Y. Moreover, reputation is not just a mental object, a piece of information we use for evaluating Y, but is an emergent sociological phenomenon, beyond the individual mind.

10.5   Conclusions

As we said, individual trust capital (relational capital) and collective trust capital should not only be disentangled, but their relations are quite complicated and even conflicting. In fact, since the individual is in competition with the other individuals, he is in a better position when trust is not uniformly distributed (everybody trusts everybody), but when he enjoys some form of concentration of trust (an oligopoly position in the trust network); while the collective social capital could do better with a generalized trust among the members of the collectivity. Agents compete and invest to cumulate their individual 'trust capital' (or 'relational capital'), even by showing their superiority and the low trustworthiness and ability of the competitors, or even by propagating false information about the others and a bad reputation (Conte and Paolucci, 2002).

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