4.1
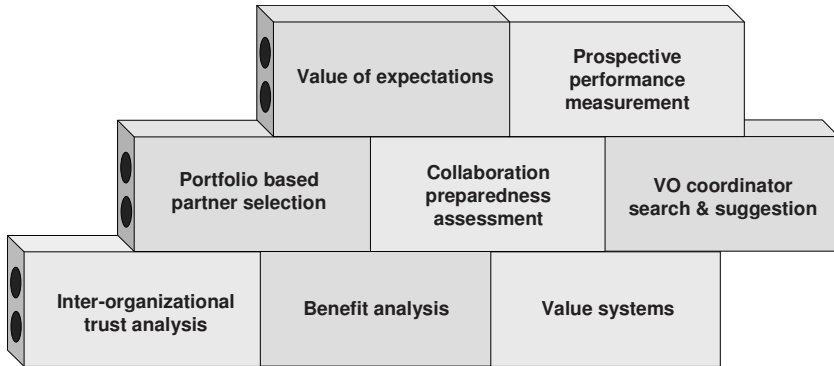## Overview

Due to the multi-faceted perspectives of collaborative networks and the wide variety of complex aspects that need to be addressed, there is no single modeling formalism or theory that can properly cover all needed modeling aspects. Very often it is necessary to combine different modeling formalisms and/or theories in order to get a more holistic perspective of CNs.

Each modeling tool / system is usually developed to sufficiently cover certain aspects within its respective discipline(s). Therefore usually several independent modeling tools and/or systems are applied in research, to model different aspects of CNs. Nevertheless, while keeping their independence, some forms of interoperation / composition among these modeling tools and systems are necessary.

Focusing on the modeling of certain aspects in CNs in which multi-modeling tools / systems are needed to be jointly applied, one of the two manners of *interoperability* or *composition* of the modeling tools may be needed to be applied, as addressed below:

i) In some cases, to fully model a certain aspect a number of modeling tools can be applied in a sequential manner, where for example the output of one model constitutes the input for another. Therefore, the modeling tools need to interoperate by sharing and exchanging some input and output elements. In this case some dependencies among the modeling tools / systems exist, and for each case some sequential interoperability of the modeling tools / systems components is required to be developed.

ii) In some other cases, to fully model a certain aspect, a number of modeling tools / systems need to be first integrated with each other into a new compound

/ composite model, which then is implemented to provide the required elements and functionalities.

In the following chapters, a number of cases for modeling different CN aspects are presented, where either the interoperability or the composition of several modeling tools / systems are applied. The purpose here is on one hand to raise awareness on the need for interoperation / composition of several modeling tools / systems applicable to CNs and, on the other hand, to address a number of CN-related aspects that require multi-modeling tools / systems for their proper representation. These two elements are addressed through focusing on some specific example cases. Furthermore in each application area we focus on either the interoperation or composition of the required modeling aspects.