This chapter introduces the first set of basic design concepts along with specification language elements to formally represent them. When considering an object of design, we make a sharp distinction between the object as a carrier of behaviour, i.e. its possible existence as a real-world object, and the behaviour itself. We use this distinction to categorise our basic design concepts.

In the first category, we introduce the entity concept as the abstraction of a carrier of behaviour, and the interaction point concept as the abstraction of the mechanism with which entities interact. In the second category, we introduce the interaction concept as an abstraction of an interaction between entities, and the behaviour concept as an abstraction of the behaviour of an entity. Interactions are assigned to interaction points and a behaviour is assigned to an entity. We discuss in detail what abstract characteristics the interaction concept has to fulfil in order to serve its purpose. We define behaviour by defining all the causal relationships between interactions that belong to one entity. Next, we discuss entity decomposition to define an entity as a composition of sub-entities interconnected by interconnection points that are internal to the original entity. Abstracting from these internal interaction points and the interactions that occur at them leads to the basic design concepts of action point and action. We finally discuss action and interaction refinement as means to come to lower levels of abstraction in a stepwise design refinement process. These concepts allow designers to model a system as a unified whole (the external perspective) and as a structure of interconnected parts (the internal perspective).

Many of the concepts presented in this chapter and Chaps. 4 and 5 have first been proposed and elaborated in [65, 66], and further worked out in [31, 67, 68].

We stress that basic design concepts should define what is essential, pragmatic and possible in practical design, while refraining from definitions or interpretations that appear impractical, non-realistic, or even impossible. In the same way, language concepts, and the rules that language concepts and language expressions should obey, should faithfully reflect the basic design concepts and not the other way around. In other words, basic design concepts and their language
representations should have a realistic, pragmatic and intuitively appealing architectural semantics. We observe that in this respect the past has confronted us with some serious misconceptions, with the ultimate consequence that formal specification has met little enthusiasm in industry [69].

3.1 A System, Its Existence and Its Behaviour

The essential steps in distributed system design elaborated in the previous two chapters form the starting point for developing our basic design concepts. Figure 1.11 summarises these steps, by showing a system at consecutive levels of abstraction, starting with the system as a whole, rendering a Service (the external perspective), and followed by a sequence of conforming systems, each system defined as a composition of—increasingly refined—parts (the internal perspectives). At each abstraction level, the system as a whole and the parts are considered both:

- From the viewpoint of what the system does: the properties, behaviour, functions, capabilities, or characteristics of the system, as well as
- From the viewpoint of what the system is (or who does it): the real-world logical and physical objects that embody the system.

Figure 3.1 illustrates these viewpoints.

We further define these viewpoints, leading to a complete set of basic design concepts. Along with these concepts, we provide language elements to express them.

We start with the concepts we need to define a system as a whole. For this purpose, we introduce the concepts of entity, interaction point, interaction and behaviour. Next, we introduce the concepts we need to define the decomposition levels. For that purpose, we introduce the concepts of entity refinement, action point, action, action refinement and conformance.

![Fig. 3.1](image-url) A system in terms of a behaviour carried by an entity