Chapter 2
Introduction to Cooperating Objects

A number of different system concepts have become apparent in the broader context of embedded systems over the past couple of years. First, there is the classic concept of embedded systems as mainly a control system for some physical process (machinery, automobiles, etc.). More recently, the notion of pervasive and ubiquitous computing started to evolve, where objects of everyday use can be endowed with some form of computational capacity, and perhaps with some simple sensing and communication facilities. However, most recently, the idea of Wireless Sensor Networks has appeared, where entities that sense their environment not only operate individually, but collaborate together using ad hoc network technologies to achieve a well-defined purpose of supervision of some area, some particular process, etc.

We claim that these three types of systems (i.e. embedded systems, pervasive and ubiquitous computing and wireless sensor networks) that act and react on their environment are actually quite diverse, novel systems that, on the one hand, share some principal commonalities and, on the other hand, have some different aspects that complement each other to form a coherent group of objects that cooperate with each other to interact with their environment. In particular, important notions such as control, heterogeneity, wireless communication, dynamics/ad-hoc nature, and cost are present to various degrees in each of these types of systems.

Fig. 2.1 shows the different weights of these functional aspects. As already mentioned, the strength of traditional embedded systems is control functionality. Pervasive computing applications include control aspects as well but usually do not have hard real-time constraints. Heterogeneity is a key aspect of pervasive computing since no common platforms can be assumed if devices of everyday’s life are cooperating. In contrast, single embedded systems and wireless sensor networks are a controlled setting where heterogeneity is typically low. If several embedded systems are combined as, for example, in a car, their heterogeneity increases. A characteristic of wireless sensor networks and pervasive computing is wireless communication whereas in contrast traditional embedded systems are wired. This has direct implications on dynamics and ad-hoc nature since wired systems are static. The dynamic nature of pervasive computing is tightly related with its heterogeneity. For wireless sensor networks there exist both static and mobile scenarios. Since many of them assume a high number of sensor nodes low cost is very important. If many devices of our environment should be integrated in pervasive computing applications the cost aspect will become more relevant especially for cheap devices. Since embedded systems are usually integrated into larger and more expensive devices the cost of the single embedded system is less important than for the other system concepts.

The conception of a future-proof system would have to combine the strong points of all three system concepts at least in the following functional aspects:

- Support the control of physical processes in a similar way embedded systems are able to do today.

P.J. Marrón et al. (eds.), The Emerging Domain of Cooperating Objects, DOI 10.1007/978-3-642-16946-5_2, © Springer-Verlag Berlin Heidelberg 2011
• Have as good support for device heterogeneity and spontaneity of usage as pervasive and ubiquitous computing approaches have today.
• Be as cost efficient and versatile in terms of the use of wireless technology as Wireless Sensor Networks are.

The convergence of these three types of technologies that, until now, have been evolving independently of each other (Fig. 2.2), is what we call Cooperating Objects technologies. This new term is born out of the combination of these traditional systems.

Moreover, this notion or paradigm of Cooperating Objects is even stronger than the individual technologies it stems from, as it carries over to their internal structure – e.g. a Wireless Sensor Network can be regarded as consisting of Cooperating Objects itself, highlighting the diversity of cooperating patterns admissible under this general paradigm. Also, pointing to the importance of complementing the vision of pervasive computing with that of pervasive control is essential.

2.1 Definition

Following the concepts we have just discussed, let us now define more formally what a Cooperating Object is: