CHAPTER S

Systems and Society

Henri has some compulsory lectures on Wednesday morning. He is not able to think about his assignment work, and not even Irene even though somewhere in his mind he is worried and peaceful at the same time. Fortunately, he has some free time before Dr. Leopard's lecture. Remembering some of the advice given during the previous lecture, Henri notices that system thinking might also be a powerful tool for improving his own relationships.

What is the metrics for a relationship between two persons? Is the relationship better the happier I am? Should I consider the combined happiness of both parts of the relationship? Or is every relationship an integral part of the community as a whole? In Henri's opinion, the traditional way of thinking has been to stress the community aspect while the modern practice is to stress individuals, even a single person in the case of a relationship.

The question of metrics turns out to be more complicated than what Henri originally thought. There are, at least, three aspects: first, who is assessing, secondly, from whose perspective, and thirdly, over what period. Besides, happiness is not necessarily the only objective of a relationship. Maybe some people rather prefer excitement, pleasure, or serenity instead of happiness, while some other people try to prove their competence or increase their self-confidence through their relationships. Of course, many think that love is The Metric. If no one really knows what love is, how it could serve as a metric for anything else, Henri wonders.

There are many other issues, like; something highly beneficial for me is not necessarily beneficial for other people. Thus, it really matters whether or not my actions increase the well-being of others. Whom do I really need to consider, only those that are my closest friends, or every human being on earth? What is a proper metric for that purpose: economic efficiency, performance of coping with everyday challenges, happiness, or something else?

As an engineer solving problems that can be solved, Henri ponders whether someone has ever tried to solve this problem by means of a mathematical model. When walking towards the lecture hall, he hopes that Dr. Leopard would be able to illuminate these convoluted matters. Maybe someone would write a book that offers an introduction to this intriguing topic.

Dr. Leopard starts his lecture by discussing about our capability to experience meaningfulness together with others. Common experience fortifies the power of experience. Henri listens to the story told by the lecturer but gradually an event that occurred on the morning fills his mind. He was already somewhat late and should have hastened, but for some reason he had an inner feeling of peacefulness. Something appeared to persuade his typically restless mind: "There is no hurry, just walk as you feel appropriate, reflect on your inner thoughts and observe mindfully what is happening around you." Just when he entered the main building, someone said, *hello*. He was really excited when he noticed who the gentleman was that had called him.

He was acquainted with him during a fascinating course two years ago. They had immediately an ability to submerge into deep discussions. Since Henri had not met him during the last year or so, he was delighted to converse with him. He forgets the obligatory lecture when he notices that they are reading the same book. Henri has bought the book because he thought that it might illuminate the question about what motivates users to buy and use applications. It turned out that his friend was doing his master thesis based on a survey study. Students filled questionnaire forms both before and after a series of lectures. The main question was whether there was any measurable change in the students' opinion or mindset, and how that change affects their studying performance. They decided to continue their mutual reflections later.

It was one of those small incidences that leaves a bizarre feeling that it did not happen by accident. Why was he so peaceful beforehand, why didn't he rush to the lecture, and what was the source of deep satisfaction during the discussion with his friend?

Now Dr. Leopard finishes his first story and shows a brief video illustrating nicely some aspect of the lecture. The video shows Mohammad Ali in Olympic Games 1996. It was a deeply moving event that still is able to touch the minds of engineering students. Henri feels strong empathy but something reminds him also about his main concern just now. He would really like to get some sign from Irene whether there was something amiss.

After the break, Dr. Leopard continues his lecture with other vital topics. He asks everyone to consider genuinely their own relationships with other people. Are they able to show appreciation for other people? There are numerous ways to do this, and one of them is to regularly do small good deeds. But what is that, Henri wonders, there is something familiar in Dr. Leopard's slide when he is telling a story that illustrates the effect of roses on woman:

Flourishator

Enrich your life

Could it be that Irene has contacted Dr. Leopard? Henri has to ask him after the lectures. Besides that is a good reason to start a conversation, Henri ponders, which may lead to something extraordinary.

To be continued in the next edition.

Systems approach

The main theme of this final chapter about systems and society is the controversy between the selfish interest of individuals and the interest of the society as a whole. Why should we care about this sort of existential question in the context of communications? The answer is that this eternal conflict is in the core of communication: without sophisticated communication human beings would solve every conflict separately, based on the force and skills they happen to have at the moment of encounter. The evolution of our species can thus be seen as an evolution of communication skills and trust. Trust is built, in addition to the personal characteristics of the members of the society, through the institutions of the society. This viewpoint to the overall evolution of humankind is depicted in Figure S.1.

There are two main messages illustrated in Figure S.1 and discussed in this chapter. First, our communication capabilities are a result of evolution. However, that does not indicate that our current communication skills would be optimal in the current complex global society, but rather that the skills have been helpful when our ancestors lived in groups up to 150 members. Secondly, the main strength of any society lies in the cooperation between the members of the society. Communication must support this crucial cooperation in order to be beneficial for the society.

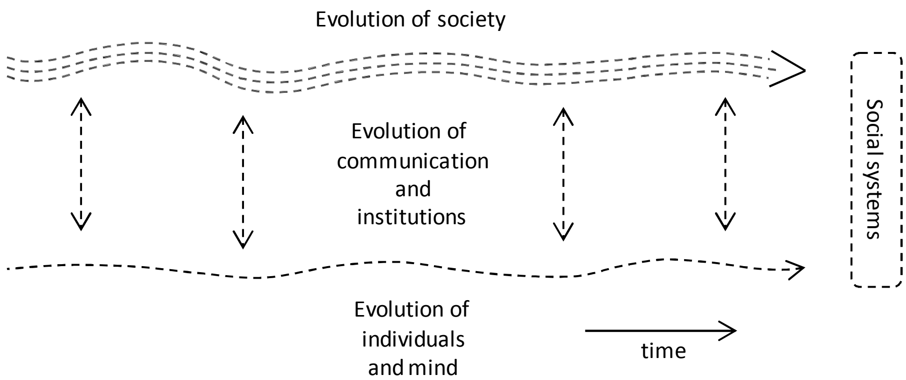

Figure S.1: Social systems as a result of evolution of individuals, communication, and society.

Various questions emerge from this simple illustration. For instance, if communication shall support cooperation, should the society prohibit any acts of communication that may endanger the harmony of the society? Particularly mass media might be considered dangerous, because it may promote conflicts instead of cooperation between separate groups of people. The aspiration to control the communication of other people within a group of people can always be considered from the viewpoint of the survival of the group of people (or autopoiesis as discussed later in this chapter). Moreover, a healthy social system needs high level of trust between members, which can be achieved only if communication is open and genuine enough.

Terms

Note particularly the prefix "eco" in ecosystem. An artificial system is good when it fulfills the objectives set by someone, whereas an ecosystem is good when it is healthy and sustainable. For instance, a communication system can be assessed separately by the designers or the customers of the system, or by the society as a whole. If the designers are not satisfied with the system, they may intentionally improve the system by adding new features or by increasing the performance of the system. Customers may also require improvements—if they remain dissatisfied, they may change to another system. In the case of communications ecosystem, societies may have clear insight about the preferable outcomes and products of the ecosystem, but rarely any effective means to design any ecosystem. Each actor assesses the ecosystem from its own viewpoint and typically in a way that supports the survival or success of that specific actor, which leads us to other important terms:

autopoiesis: a process whereby a system, organization, or organism produces and replaces its own components and distinguishes itself from its environment,

career: a course of professional life or employment, which affords opportunity for progress or advancement in the world,

communication: a process by which information is exchanged between individuals through a common system of symbols, signs, or behavior,

ecosystem: a community of organisms together with their environment, viewed as a system of interacting and interdependent relationships,

efficiency: the extent to which a resource is used for the intended purpose,

evolution: a gradual process in which the properties of a group of similar entities change because of interaction between the entities and their environment,

fitness: the ability of an entity to both survive and reproduce,

game: a contest with rules to determine a winner,

institution: the laws, informal rules, and conventions that give durable structure to social interaction among the members of a population,

interaction: the reciprocal influence of two or more things that have an effect on each other,

language: a systematic way of arranging symbols to express meaning,

society: a group of people who share a common culture, occupy a particular territorial area, and feel themselves to constitute a unified and distinct entity,

system: an organized structure regarded as a whole consisting of interrelated and interdependent elements, and

worth: the level at which someone or something deserves to be valued when all relevant aspects are taken into account.

The following terms explained in Glossary are relevant, too:

architecture	culture	expert	process
boundary	deterministic	free rider	selfishness
butterfly effect	dissemination	game theory	self-reference
CEE	diversity	mass media	social
co-evolution	domain	metalanguage	social group
commons	emergence	metaphor	social status
community	entity	mutation	structural coupling
conflict	environment	phenomenon	structural portability
convention	equilibrium	positivity	systems intelligence
cooperation	existence	power	tragedy of commons

Evolution and development

One aspect of complex systems that seems to be amazingly difficult to grasp clearly is the difference between intentional development and evolution as an unintentional process. I attempt to clarify this issue, also by means of systematic terminology. It is useful to make a distinction between two extreme systems: one that just evolves without any external control or aim and another one that is intentionally developed. In brief, if a system evolves then there is no predefined aim towards which the system is evolving. If the system is developed, then there has been an agent with the intention to develop the system towards a defined target.

Nevertheless, a casual observer might interpret also an evolutionary process as going towards a pre-defined goal. For instance, it is easy to think that the aim of natural evolution (or selection) is to develop more capable living things, or maybe more intelligent beings. We can assume that we are now more intelligent than our ancestors were 30 million years ago. Still, we should not make the conclusion that this proves that increasing intelligence has been the predefined *purpose* of our evolution. Based on the evidence we now have, we shall rather think that the biological ecosystem as a whole has evolved in a way that billions of human beings can just now populate the earth at the same time. Some of them seem to be intelligent, at least from the perspective of other human beings. Whether other, non-human living beings think in the same way, we cannot know.

As another extreme, we can observe a complex communications device that has been developed by group of engineers. First, before the actual development of the device, some general objectives are determined, then those objectives are translated into a set of required features, and finally a strict set of technical requirements is defined. After these phases have successfully passed, it is easy for anyone to predict what will the final result—at least, if the group of developers has enough competence, resources, and time to finalize the development effort. The same requirements could be given to two distinct groups without any interaction between groups. Still, an observer may predict that the results are similar, even though the observer is not able to predict what each member in both groups is doing at certain point of time. If you were just able to observe the groups as an outsider without knowing anything about technical requirements, the similarity of their outcomes would be a surprise for you.

Let us think about a system that contains entities that can be observed. An entity might be anything observable: table, species, word, idea, number, book, gene, IP packet, sunny day, funny movie, student in a bar, etc. The main point is the following: when an observer observes the system, he needs to select what he wants to observe by defining criteria for each type of entity. Thus, an observer must be able to generalize entities into groups that share some fundamental properties, such as a book is an object consisting of pages fixed together typically with written text. Whether or not e-books belong to the same category as ordinary books depends on the selection criterion.

The fact that those criteria do not necessarily ever reach the conscious mind does not lessen the importance of the criteria, quite the reverse, the automatic selection of criteria is an indication of the central role of the process for our lives. If a person loses his ability to classify objects, he may mistake his wife for a hat as occurred in the famous example described by Oliver Sack (2010).

The observer is typically able to count (or at least, estimate) the number of observations that he interprets to satisfy the predefined criteria. For illustration purposes, we can assume that the observer is totally separate from the observed reality (although in reality this is rarely the situation, except in the case of astronomers observing distant stars). The fundamental idea here is to show that something that is easily interpreted as intentionally created can evolve by itself under certain conditions.

Figure S.2 shows a system with a number of entities (rectangles) filling a place for certain period. From the perspective of the observer, each entity first appears and then disappears. Note that the period depicted by a broken line can be observed only by a meta-observer (you, the reader, and me, the author), but not by the observer shown in the figure. Thus, it might well be that the entity, using some other criterion than the observer, exists before it could be observed, and it may disappear from the observer before the entity ceases to exist.

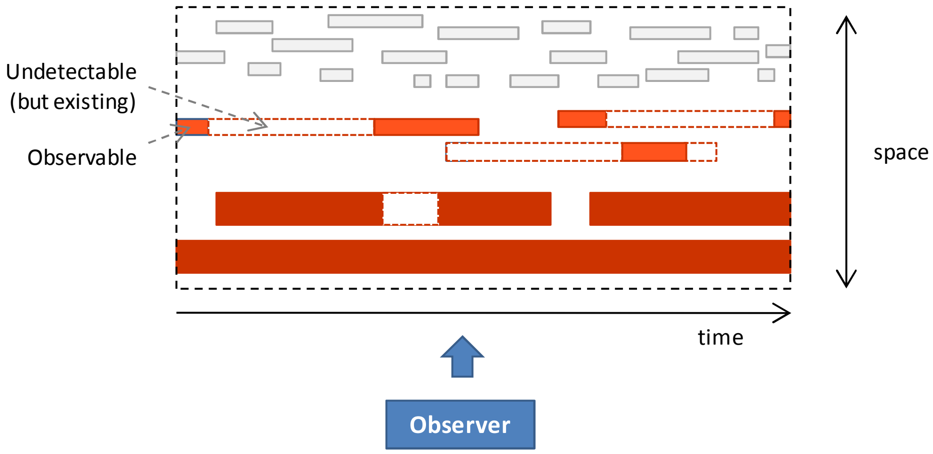

Figure S.2: An observer and entities to be observed.

For modeling purposes we need to assume that new entities of a certain type are born according to some process, and that they die according to another process, and finally that an existing entity can be observed according to a probabilistic process. In addition to the existence of an entity, the observer may also discern some qualities of the entities (color) and the volume of the entities (height of the rectangle). Both the qualities and volumes may vary over time, although these changes are not illustrated in the figure.

Note also that a neutral observer does not carry out any assessment on the good-bad or better-worse dimension; all observations are neutral in that sense. An observer may make, however, separately her own assessments about the desirability of different states of reality, such as about existence, volume, quality, diversity, or something else.

Desirability assessments may vary vastly depending on the observer. The entities may represent species of birds in an area, for instance, small rectangles are sparrows, medium rectangles are hummingbirds, and large rectangles are sparrowhawks. If the objective of a researcher is to study sparrowhawks, he likely considers it better that sparrowhawks will flourish or at least survive rather than die away. Another person may feel sympathy towards small sparrows and, thus, have an opposite opinion. Someone might only be interested in the hummingbirds because of their beauty while the fate of sparrows remains indifferent for her. Finally, there are people that believe that it is right that the strongest survives—and the strongest one is that which survives.

Note particularly that when making objective observations the observer should not assume anything about the purpose or value of the entities. The observer may make an interpretation about the characteristics of observed reality, but in general, that process occurs in the mind of the observer. In this sense, the observed characteristics of the entity are not a property of the entity itself. Thus, we have to suppress our innate tendency to attach terms like desire, aim, optimizing, or intentions, to all kinds of entities. For instance, viruses, flowers, words, and numbers do not have any aim by themselves. They can be used by an agent to pursue something. To use the terminology of Niklas Luhmann, all kinds of entities can be used to utter something as a part of a communication process. Flowers certainly have ability to tell something as a part of human interaction. In that case, the desirability assessment is not directed towards the observed entity, such as a flower, but rather towards the observer herself: as to what kinds of emotions the observations is able to create in the observer.

In the framework of this book, those passive entities, when observed by themselves outside of any meaningful context, do not possess their own purpose or meaning. Yet different attitudes towards this philosophical subject are possible and acceptable. Whether or not animals have their own will, is a question not addressed here (although I personally believe that at least some animals do). Thus in the context of this book intentions, desires, and aims are restricted to the human mind and organizations in which human minds are in a central role, that is, social systems.

In contrast, it is not correct to state that the intention of a (biological) virus is to reproduce itself, or even less, to get as many people sick as possible. If an observer observes, first, numerous sick people, and, secondly, a huge number of viruses of a certain type, we shall not conclude that the viruses had any aim at all. Moreover, the viruses did not try to evolve in a way that their number could be multiplied as quickly as possible. What really did happen was that a large number of mutations occurred resulting in various types of viruses. Some of the types were more efficient in reproducing themselves than other types, in the particular environment where the viruses happened to exist. The observer likely observed much more of those types of viruses that were efficient to reproduce. We may state that the observed viruses have had higher fitness than other viruses. However, that statement only means that we attach a label (differences in the fitness) to something that existed in the past. Yet, we need to be cautious when attaching a quality called fitness to the entity itself. Maturana and Varela (1992) and Talbott (2011) and many other books and articles provide additional insight in this topic.

An observer observes the amount of entities of types 1, 2, and 3, at t_1 and t_2 as illustrated in Figure S.3. It seems feasible to claim that the entities of type 1 had better fitness than entities of type 2 and 3 during the period from t_1 to t_2. The problem with fitness as a term is that it sometimes gives excessive emphasis on the fixed, internal properties of the entities. A casual observer may think that an animal of type 2 has "better" genes and capabilities than an animal of type 1. However, the same properties that made type 1 common at t_1, may be the reason for its decline between t_1 and t_2. In any complex system, what one observes depends on the interactions within the system as much as on the characteristics of the separate entities. The average properties (for instance, the relative appearance of certain genes) change from t_1 to t_2 even though we do not need to assume any changes in the properties of type 1 and type 2.

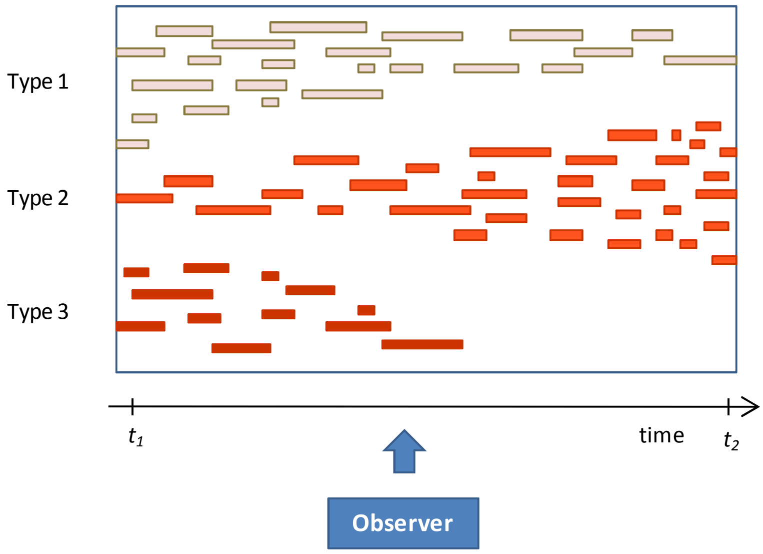

Figure S.3: An observer and three types of entities.

From the perspective of this particular observation, indeed, type 2 performs better than type 1. Nevertheless, we need to be cautious with the term "better" unless we clearly define the metric that is used to assess what is better and what is worse. From the viewpoint of observations, the most unambiguous criterion is survival, because it is impossible to observe correctly something that does not exist (note that then the event of observing an entity is defined as more desirable than a lack of any observation).

Then if we consider the size of an entity, for instance the total revenue, profit, market share, or market value of a firm, it is not evident that bigger is always better. Particularly, the size of an entity does not automatically entail the survival of the entity. One may think that likelihood of survival is *The Criterion* for assessing what is better and what is worse. All the same, that is a choice among many feasible choices.

Let us consider an artificial rectangular system with 100 cells, $S(i,j,k)$, where *i* and *j* defines the position of the cell in vertical and horizontal dimensions, respectively, and *k* defines the phase of the system. The system evolves according to the following rule: $S(i,j,k+1) =$ the number of neighboring cells in which the value at phase *k* was the same as $S(i,j,k)$. Neighboring cells of cell $S(i,j)$ consists of those cells in which both i and j differ at most by one. In addition, in order to give an equal position for all cells we define the following equalities: $S(0,j) = S(10,j)$, $S(11,j) = S(1,j)$, $S(i,0) = S(i,10)$, and $S(i,11) = S(i,1)$.

We can predict exactly how the system will evolve over time (here we assume that *k* means time). Because each cell can take nine different values and there are 100 cells, the number of possible combinations is $9^{100} \approx 2.6 \cdot 10^{95}$. However, not all combinations are possible as a result of evolution because of the properties of the algorithm (for instance, 0 and

8 cannot be found in neighboring cells). Still the number of possible combinations, or system states, is huge.

The phenomena to be illustrated by this simple system are:

- it is not clear what are the entities we should observe,
- strictly deterministic systems tend to produce repeating sequences,
- we are more likely to observe states that are part of a short sequence,
- mutations may destroy the predictability, and
- mutations can be considered as intentional interventions.

Figure S.4 shows a simple starting state in which four cells in the middle have value 1 while all other cells are filled by zeros. Because the system is highly symmetric at the start, the system maintains the symmetric properties throughout its evolution. Various patterns emerge until the phase 111 which "happens to be" identical with phase 108. Thus after phase 111 the "evolution" of the system is easy to predict.

Because of the deterministic nature, the system will at some point of time (or phase) start to repeat a sequence of states. Thus if we observe a sufficient number of phases, the probability of observing a state belonging to a short sequence is much larger than the probability of observing any other state. Anything that makes the system more stable (or here, to repeat a short cycle) significantly affects the observation probabilities.

Now in this case, the state at phase 110 is something that will be observed more likely than almost any other state. Does that fact make that state somehow better than the other states? The right answer might either be *yes* or *no*, depending on whether the observer prefers stability or diversity. Furthermore, the patterns and colors may also resemble a flag of a country or a team, and as a result, evoke positive emotions. The repetition of the pattern might be thus be interpreted as sign that the country or the team is somehow special.

The system is indeed perfectly predictable if there are no exceptions, or mutations in the algorithm. What will happen if we change a little bit the starting state or if there will be a small irregularity in the algorithm? A comparison between Figure S.4 and Figure S.5 illustrates the situation: the only difference between them is the value of one cell at the starting phase is changed from 0 to 1. The effect of this change is limited during the first three phases, but already at forth phase there is almost no visible similarity in the two systems. In general, there is no noticeable correlation between two systems after seven phases although they differ only in one cell in the original state. A small change in the system shown in Figure S.5 means that it will take very long for the system to reach a state with a limited sequence of phases.

Symmetric patterns and sequences are somehow alluring; it seems that evolution has favored individuals that prefer, for instance, symmetric human faces (thus, the symmetry in Figure I.1 is not a coincidence). However, from the viewpoint of this discussion more random systems than the starting state are interesting. Could it be possible to state something "useful" about the evolutionary process of the system?

Figure S.5 also shows how the system evolves after numerous phases. It seems, when looking the patterns at the phases from 1370 to 1374 that there are somehow predictable fluctuations between states with smaller and a larger numbers. For instance, the number of cells with value of 4 or larger is 24 at phase 1370, 6 at phase 1371, 16 at phase 1372, 2 at phase 1373, and 31 at phase 1374. This sort of behavior may lead to a conclusion that some level of predictability is possible without making exact calculations. Even though this might be the case, accurate predictions or interventions seem to remain very difficult unless all the necessary calculations are made carefully.

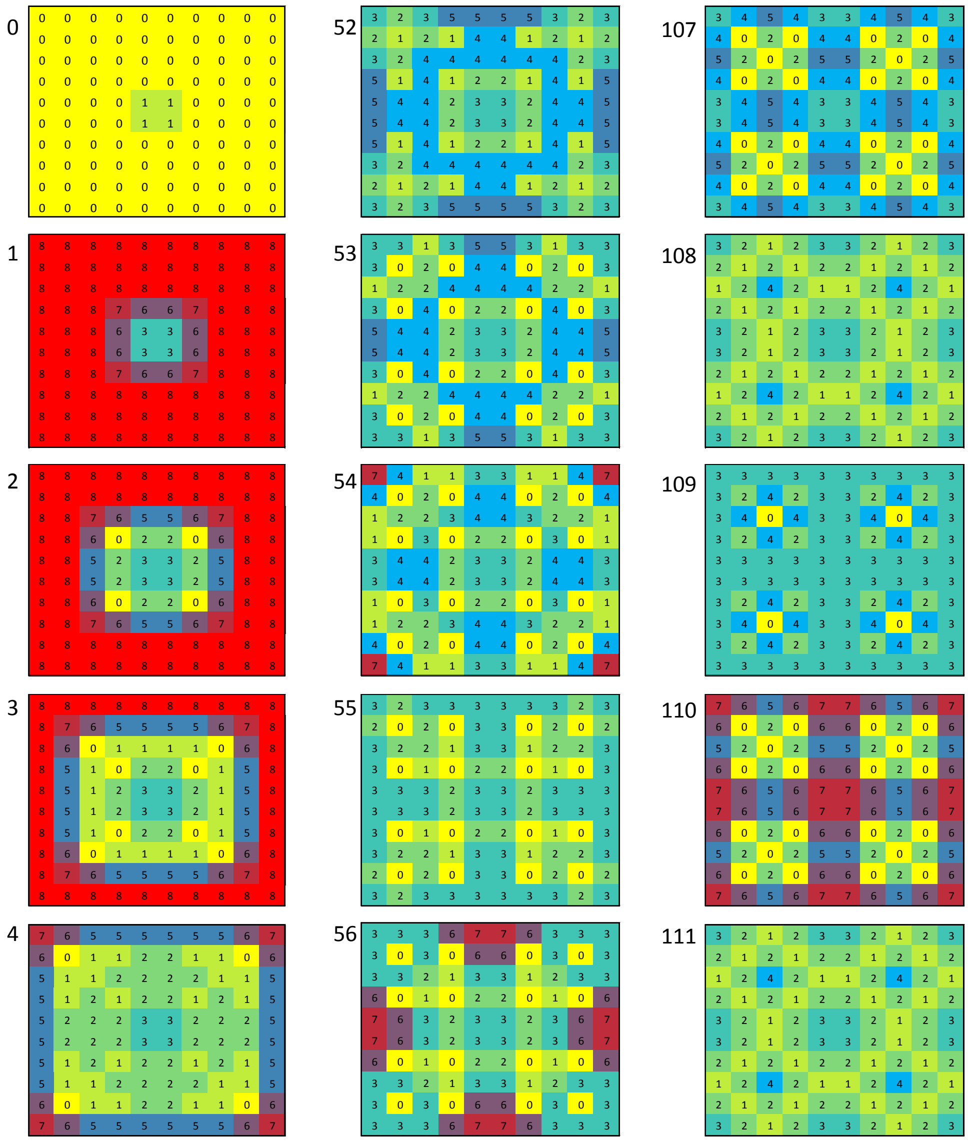

Figure S.4: A system evolving according a simple algorithm. The system starts to repeat a cycle of three steps at phase 111.

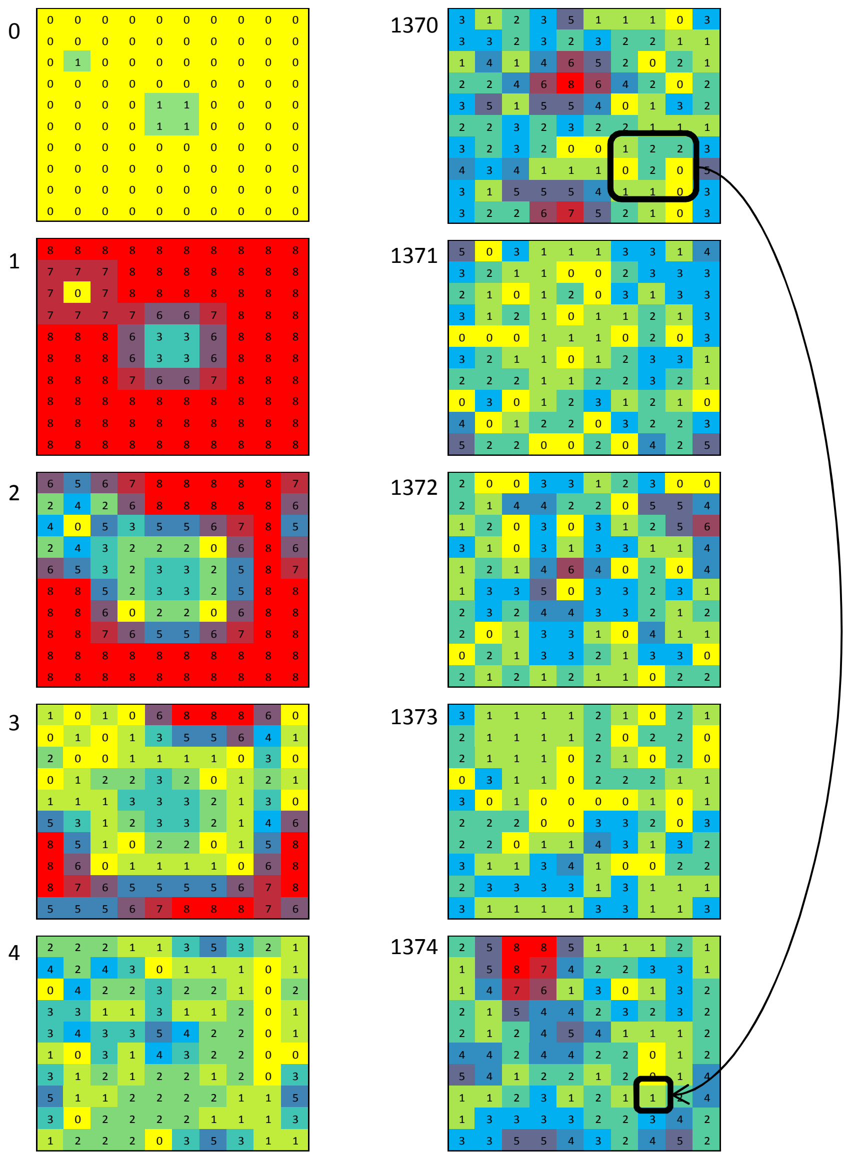

Figure S.5: A change at phase 0 compared to system in Figure S.4. System evolves after forth phase without any obvious regularity.

Let us assume that someone wants to produce a number 8 in a certain cell at phase 1374 by changing the content of the cell and its neighbors at phase 1370, as illustrated in Figure S.5. The task is possible to carry out, because the system is deterministic and it is easy to make the necessary calculations. On the contrary, if we consider a situation in which not all calculations can be made exactly, the idea that large values at a certain phase produce smaller values at the next phase, and vice versa, is not useful for predicting or controlling purposes. In contrast, it seems that the only workable way to make predictions is to systematically go through different combinations of values and calculate the outcomes that follow. Moreover, the accuracy of any prediction made at phase *k* concerning the state at a later phase *m*, can be destroyed by a single mutation at any phase between k and *m* - 6. This could also be called the butterfly effect, that is:

> **butterfly effect:** a condition in which a small change at one place in a nonlinear system can result in large differences in a later state.

Note also that it is quite questionable to assume that any repeated sequence is intentional, or that the system has an objective to reach a stable and visually attractive pattern. If there is any intention, it has been in the mind of the author of this book, not in the system itself. Besides, the system in Figure S.4 is highly unstable, which means that the system does not usually return quickly to any stable state or sequence after a disturbance or intervention.

Still, even if we are not able to develop accurate methods to predict outcomes (other than complete calculations) we can make some statistical analysis. Figure S.6 shows the frequency distribution for different values when the system starts from a random state. Thus, we know that the probability that a random cell contains number 6 is about 1 percent, unless we observe a system with a short sequence of states. We could also construct predictions that are more complex: if we know that a certain cell contains a value of 7, the probability that an adjacent cell contains number 6 is about 25 percent instead of 1 percent. This kind of statistical insight might be useful although we have in principle perfect knowledge about the behavior of the system.

From this perspective, biological viruses and computer viruses are of different natures. Someone has always (as far as I know) designed every computer virus, typically with the deliberate *intention* of doing harm for some people or organizations, reaping benefits at the cost of other people, or gaining reputation among peers. Surely, it is conceivable that a computer virus might emerge spontaneously, but the probability of that kind of occurrence is much smaller than the probability of the intentional development of a new virus.

Figure S.7 illustrates the situation. An observer has observed a system for a period. Then he describes the state of the system by two parameters, x and y. At the start of the period, the system is in state A and at end of the period in state B. The path of the observed entity during the period is curled and hard to measure exactly.

The observer may assume (because of reasons that are not directly related to the observations) that the purpose of the system is to develop towards goal G. The goal might be either a point or direction. For instance, a possible assumption is that the purpose of human evolution is to develop more enduring, satisfied, or intelligent people. Observations seem to support this assumption, at least to some degree. If the observer just continues to observe without any intervention, it does not matter much whether there indeed is a goal or the system just evolves without any real goal. On the contrary, the situation is different, if the observer decides to interfere with the system, for instance, by pushing it upwards on y-axis. Let us assume that the push has a desired short-term impact in a way that the system moves to state C.

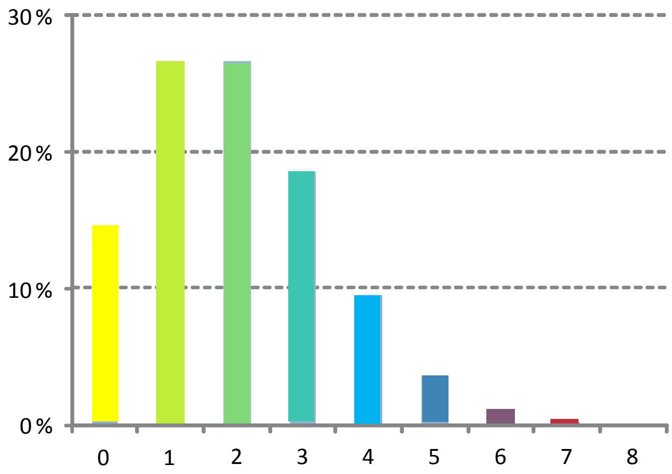

Figure S.6: Distribution of values in case of system with a long cycle.

Now the assumption about the existence of the goal is important. If there is a goal, the system is likely to evolve towards its original goal, and after some time it may reach state D nearer the desired goal. In contrast, if the system has strong enough stabilizing feedback loops, the system likely returns to state F near the state before the intervention (B). Finally, if the system happens to have several equilibrium states, it may evolve to any direction, for instance to one of the equilibrium states, E. Note also that any outcome can be explained by a goal: the observer just did not know beforehand the correct goal, or the goal might have changed between two observations. Therefore, although we can interpret almost any type of evolution because of intentional goals or purposes, we should usually avoid assuming a clear goal to an evolutionary process, because that assumption may lead to misleading reasoning.

Often we do not explicitly claim that evolution goes towards a specific goal, but still our terminology appears to imply a goal or purpose behind the observed behavior of the system. If the main reasons behind the observed pattern of a system behavior are the system's internal structure and interactions between the parts of the system, then it is unlikely that the state of the system could be changed by just changing the goal of the system or by changing the goal of persons working within the system. For instance, we may ask: what is the goal of a pond with numerous species interacting with each other? Diversity, perhaps, but that is just an interpretation of an observer. It appears strange to think that a pond has any intention by itself.

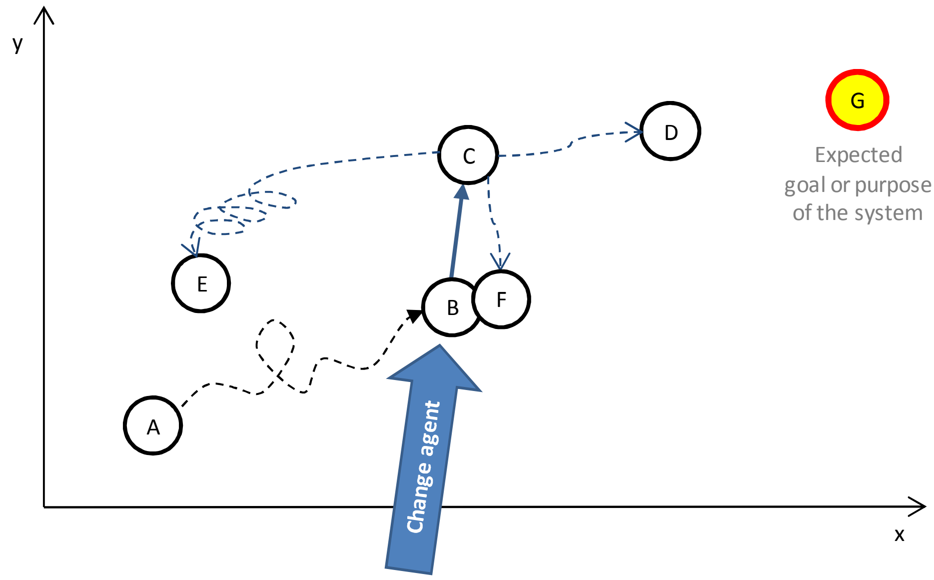

Figure S.7: System evolving from state A to B, pushed intentionally to state C, with three possible subsequent developments (D, E, and F).

Let us consider a system in which x = longevity of people and y = happiness. It seems apparent that the goal of the society is somewhere in the upper right corner of the figure (point G). Now the society may attempt to enhance the happiness of the society by increasing the consumption level of all people, because people supposedly become happier when they get what they want. Furthermore, according to statistical evidence happier people tend to live also a little bit longer. So goes the reasoning, and indeed, the society may reach point C after a while.

Remember always when you consider situations similar to Figure S.7 that the action that has an intention to push the system to a certain direction seldom directly affects the desired characteristics. An action of increasing consumption levels by reducing production bottlenecks might appear clever and justified, but it in the long term the action has many other effects than increased wealth and happiness. Note particularly two aspects:

1. Consumption consumes resources and when resources are totally consumed, there is no consumption anymore. This feedback loop is typically much longer than what we usually are willing and able to assess.
2. Happiness, as with all other emotions, has also an instrumental task in controlling the behavior of a person in a way that is beneficial for the prosperity and survival of the person. Although a permanent, intense happiness may appear desirable, that sort of state might disturb those necessary mental processes that make it possible to cope with everyday challenges. Because of that instrumental task, it might be diffi-

cult to raise the overall happiness level significantly above a kind of set point that is optimal from the perspective of the controlling task.

Rogers (2003) provides excellent examples of all the developments depicted in Figure S.7. As to the worst outcome (E in Figure S.7), the case of steel axes introduced to an Australian aboriginal tribe is illustrative (see Rogers 2003, p. 449). The tribe traveled in small groups over a vast territory. The culture was based on the use of stone axes, not only in practical tasks like construction of shelter but stone axes had also a vital role in the social organization of the tribe and in the relationship with other tribes. From the viewpoint of missionaries, it was obvious that steel axes were better than stone axes and would improve the well-being of the tribe. Certainly, steel axes are more efficient than stone axes in many practical tasks. However, the steel axes devastated the elaborate social and religious system of the tribe.

As to the outcome of type F in Figure S.7, the case of miracle rice in Bali provides a convincing example (see Rogers 2003, p. 50). The cultivation of rice on the steep slopes of mountains in Bali has been developed over several centuries. As a result, the irrigation system has reached a state that includes a hierarchical system of Hindu priests that controls the whole ecosystem of rice cultivation, including water flows and rice-planting schedules. When new rice varieties became available in the 1970s, the Indonesian government's intention was to increase rice production by introducing new rice varieties and by increasing the number of crops from two to three per year. The aim was good but the result was terrible. The new system has many undesirable effects like increasing pollution, rice diseases, and the number of rats. Consequently, rice yields dropped dramatically. Farmers moved back to the traditional system.

A common element in many negative outcomes of interventions made by outsider change agents is that change agents are not able to understand the social aspects of the change. In the worst case, the agents just believe that a mere capability (of a technical or other innovation) is enough to guarantee the desired, positive outcome. If a steel axe is more capable than a stone axe as a tool, then the steel axe is assumed better regardless of the properties of the social system. This is a dangerous attitude and unacceptable for anyone who claims to be an ecosystem expert. A broader perspective of the ecosystem must always be considered carefully. The consideration must include collective effects (direct effects to others), cost aspects (both for those that benefit of the change and for outsiders), and system effects (how the system would likely adjust after the intervention). Only after considering all of these aspects, can an expert make a credible statement about the worth of the change.

Predictability

Paradoxically, intentionality may also decrease the predictability of a system. If there were only one actor who has a clear intention to reach a certain goal, the prediction of the outcome would sometimes be easy. For instance, let us consider two random locations on a random day. If only one person had firmly resolved to run between those two locations during a day faster than anyone else did, his intention would likely be fulfilled, because it is unlikely that any other people would just randomly run between two given locations. On the contrary, if another person promises a big reward for the fastest runner between the points, it is much harder to predict the outcome. In that case, a predictor would need to predict both the intentions and the capabilities of many other people.

As a result, in order to have an accurate prediction of the future behavior of the system the person has to model the other actor's intentions and behavior. Then the other actor wants to do the same for the first agent. This means that the first actor has to model his own behavior in order to model the behavior of the other actor. This phenomenon was called *double contingency* by Niklas Luhmann (see Moeller 2006 or Luhmann 1995).

The degree to which we are able to model double contingency as a statistical process is an open issue. In general, we may consider a situation in which a person needs to make a decision between choices A and B. Our task is to predict the consequences of these two choices. In principle, we may have three types of beliefs about our abilities in this situation:

1. Everything that follows the decision is deterministic. Thus, every decision has in principle definite consequences. However, we are unable to make perfect predictions because of the limited knowledge about the current situation and because of the limitations of computational resources.
2. Other decisions made by other actors (as well by the original actor) with free will follow the first choice. Furthermore, all the ensuing decisions can be appropriately predicted by means of statistical models and distributions. Thus, although free will exists, the collective behavior of large number of actors can be described by probabilistic models.
3. There will be numerous free decisions after the original decisions, and all those decisions have to be considered separately. No model can ever predict free decisions. Thus, the prediction of the future is in principle impossible.

The standpoint of this book is that we shall largely abandon the first option. If there is one decision that requires investigation because it is not clear which option shall be taken, it is extremely unlikely that that it will be the last unpredictable decision ever made by anyone. Although we could imagine situations in which there are obvious immediate consequences of doing this or that without any significant long-term consequences, those situations rarely are of any significant interest. Almost all relevant cases we want to explore in the context of this book include numerous decisions made by several actors in a way that a complex, dynamic system of interactions emerges. In those kinds of situations, we shall never state that a decision will generate a certain set of exact results.

However, we cannot either apply the third choice in the list without considerably limiting the number of decisions we are considering separately. Thus, the approach adopted in this book is a combination of beliefs 2 and 3. If we look at a certain phenomenon, like setting a new price for service, we have to assume (in the model) that customers react according to some probabilistic model to the new price (even though they might have free will to decide whatsoever they want in every separate case). We cannot consider, of course, the (in principle free) decisions of every customer separately. In contrast, it seems reasonable to consider separately how other service providers will react to the changed situation of the market.

Furthermore, after making some assumptions about those decisions, we have to consider how the original service provider reacts, and so forth.

This is exactly the purpose of an analytical tool: to facilitate a step-by-step analysis in the case of complex ecosystems. Yet it is possible to continue this process. For instance, after several rounds of analysis have been made, we may be able to develop statistical models to describe the likely behavior of other service providers. But that is rather a model describing the insight of the persons doing the analysis rather than a model describing the behavior of service providers.

Furthermore, it is possible to construct a meta-level model for analyzing the process of those price-related decisions. An ordinary approach is to consider the system as a game with a number of players or service providers that tend to act selfishly. A mathematical model can be used to assess the behavior of all actors if they act somehow rationally or at least consistently. This game-theoretic model can be used to assess which kinds of market conditions are most likely to emerge because of selfish actions. If the number of active players is small (for instance, three major service providers) the outcome is anyway highly uncertain. It might turn out that in case of three players prices will remain constant even when the costs of service provisioning are going down. No one is willing to start a price war unless he is feeling anxious or frightened, and suspects that another service provider is planning a price war. This sort of situation tends to be unstable and may change radically even after a minor disruption. Those disruptions would be extremely difficult to predict. Besides, at that level of analysis there are many other actors, such as new players entering the market with a new strategy, and regulators trying to accelerate the overall competition.

Individuals as a part of a system

In Chapter H, we discussed the fundamental goals of our life by using concepts of sense of significance, sense of coping, and happiness. The question briefly addressed here is: how do different goals affect the observable behavior of the society? This question is closely related to the difference between observations, emergence, and intention. We may think in the following way: what we can observe is the overt behavior, and this behavior depends on the often unconscious goal that the entity tries to reach. Figure S.8 illustrates this phenomenon. We may assume that goal A is to maximize sense of coping, goal B is to maximize sense of significance and goal C is to maximize happiness.

Behavior, in turn, affects the survival of the entity. Thus, an observer is more likely to observe a behavioral pattern that improves the entity's survival or reproductive capability than a behavioral pattern that does not affect or is harmful for the entity's survival capability. If a person purely tries to maximize her short-term happiness, while ignoring sense of coping and sense of significance, the likely consequence is that her survival capabilities would be de-creased. In contrast, sense of significance might be useful for survival, on the condition that also other people in the community put significant stress on sense of significance. In general, this reasoning does not imply anything about what goals are better than others; it just reminds you that the goal might have indirect consequences that may appear either desirable or undesirable.

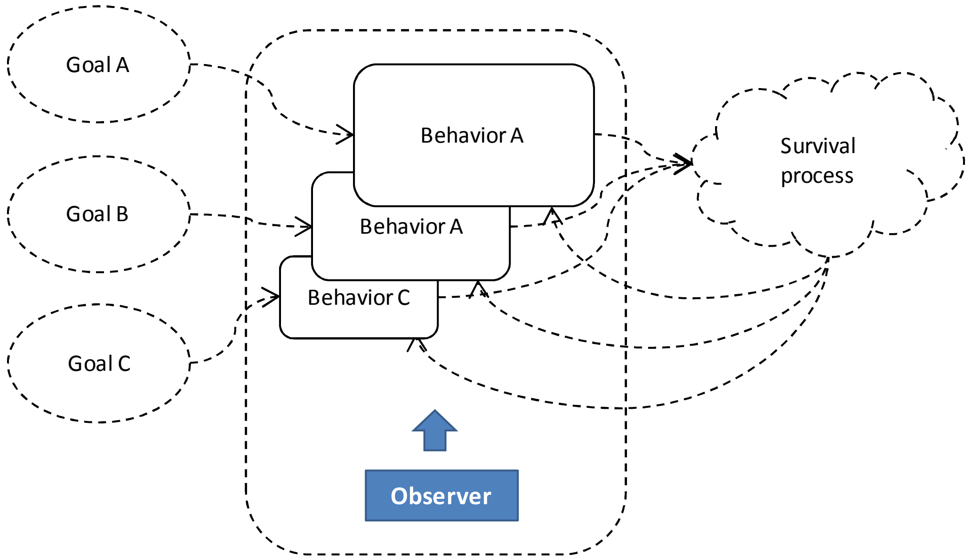

Figure S.8: Observing the frequency of a behavior (illustrated by the size of the box), when the goals and survival processes (dotted lines) are difficult to observe directly.

Yet, we need to keep in mind that the behavioral system as a whole is much more complex than what is illustrated in Figure S.8. Even though sense of coping (or ability of coping) is obviously an integral part of survival, I do not claim that sense of significance is irrelevant for survival, quite the opposite. From an evolutionary viewpoint, there has to be a connection between sense of significance and our behavior and actions. What is, then, the evolutionary background of sense of significance? Although I cannot provide any firm answer, it seems plausible to assume that sense of significance primarily directs our behavior in a complex social environment. A similarity in the beliefs about what is important in life enhances the cohesion of a group of people and, thus, improves the survival of the whole group. For instance, a tradition of taking care of all people regardless of their capabilities and wealth likely strengthens the society and thus increases the chance of survival of the society.

One of the most fundamental dilemmas in human life is the tension between the interest of an individual person and the benefit of the society. Why should a person care about anything other than herself or himself? Let us consider an entity other than a human being; it can be an organization consisting of people or it might even be an abstract concept or a non-living thing. We are inclined to state that every entity should respect its historical background. What does this respect mean in reality? I would say that it means preserving the most essential characteristics or qualities of those entities that have preceded the entity under scrutiny, and if possible, enhancing those characteristics or qualities.

Thus, we may think that the fundamental *purpose* of an entity is to transmit or forward something that the entity has inherited from its ancestors. This something can be genes, wealth, idea, belief, shape, capability, etc. Another expression of the same idea is to say that the purpose of an entity is to realize its potential to the fullest during its existence. The difference between these two expressions is that the first one stresses the continuation from past to future, while the second one stresses what happens for the particular entity during its existence. Both of these perspectives are problematic if they are considered alone. On one hand, if every entity is just a transmitter, when and where are the "true benefits" obtained? On the other hand, if no entity transmits anything forward (but just realizes its own potential during its lifetime), the chain of the quality carried by the entity will be broken immediately. Hence, a balance is needed between these two aspects.

If we look at an ecosystem, we can observe all kinds of entities and actors. When we select one type of entity for special inspection, we tend to assume that anything serving the purpose of that entity is desirable and good. The ecosystem under study may also be savanna with rangers, lions, hyenas, gazelles, ants, grass, and rocks. Correspondingly, a communications ecosystem may consist of regulators, vendors, service providers, customers, employees, applications, and devices. Obviously, many events both serve the purpose of one entity and hurt the purpose of another entity. As a communications ecosystem expert you have to be able to shift your viewpoint flexibly between different actors and entities. Even more importantly, you must be able to observe and study the ecosystem from as neutral or objective viewpoint as possible. Then the key question is: what shall be considered the purpose of the ecosystem as a whole? In contemporary biology, the most popular answer seems to be biodiversity.

Although diversity might be a proper attribute also in the case of communications ecosystem, I would sketch a different kind of answer. The answer depends on how we see the "true benefit" in the case of human beings. In my opinion, the only matter that we can take as a neutral starting point is conscious experience, in other words, the experiences that we perceive around us every day (for more profound discussion see Harris 2010, Haybron 2003, and Layard 2005). This does not indicate that anything truly beneficial cannot exist outside our conscious experience—maybe there indeed are immaterial spirits that affect our life somehow. However, it seems exceedingly difficult to include those kinds of aspects in a systematic, consistent analysis. Yet, I am comfortable with the fact that many people consider something imperceptible as an essential part of their sense of significance. Besides, one of the findings of positive psychology is that religious beliefs tend to have positive effects on life satisfaction. Furthermore, even if we do not explicitly include environment in the eudemonic evaluation, external effects (for instance, the suffering of animals) can be included through sense of significance.

The ability to cope with everyday challenges is absolutely necessary to sustain the ecosystem we are living in. However, we are inclined to overrate the importance of obvious measures for sense of coping, such as wealth, power, and competence. We may think that the aim of an entity (from an evolutionary viewpoint) is to feel the "right" emotions, created during the evolution. This is one way of thinking, but surely not the only one.

Modeling the well-being of society

Human beings are emotional organisms. We tend to analyze many situations from the viewpoint of an individual person, because that is how our mind works. The aim of Figure S.9 is to give an outsider viewpoint in order to get some insight of the consequences, both desirable and undesirable, of the process of analysis. Figure S.9 illustrates a small society of 100 persons. The persons are divided in two dimensions. First, there are high wealth and low wealth people in a way that wealth directly defines the sense of coping of the person. Secondly, for some people sense of coping is more important than sense of significance when they assess their eudemony, while for some other people the reverse is true. As a result, the society consists of four different groups of people described in Table S.1.

Table S.1: Eudemony estimation for four groups of people.

	Weight for		*Current value of*		*Eudemony (0-100)*
Group	*SoC*	*SoS*	*SoC*	*SoS*	
A	0.7	0.3	0.9	0.6	81
B	0.3	0.7	0.9	0.6	69
C	0.7	0.3	0.7	0.8	73
D	0.3	0.7	0.7	0.8	77

This sort of abstract description of a society incites only a limited amount of emotions; whether the size of black areas is smaller or larger is quite a trifling matter. Still Figure S.9 is able to accurately illustrate the total well-being (or eudemony) of the society if the individual values are correct and if we trust on the overall construction of eudemony. In this respect, the figure is more credible way to assess the total well-being of the society than an analysis based on direct emotional reflections. By the same token, Figure S.10 depicts the overall eudemony of a society consisting of 10 000 people. Thus, the content of Figure S.10 should be 100 times more important than the content of Figure S.9 and 10 000 times more important than the content of a figure illustrating the eudemony of an individual person (as illustrated in Figure S.11).

Unfortunately, it is difficult to feel the importance when the number of related people is large. It is easier to feel sympathy for a single person who has suffered than for, say, 10 000 people that have suffered in an equal way. It might be that our mind is incapable of generating clear feelings about the fate of groups larger than 150 people. If we consider Dunbar numbers (see discussion in Chapter U), we are primarily concerned about the closest five people or so, then somewhat less concerned about the fate of the closest 10 people, and even less concerned about the fate of any larger group. That is the primary nature of our emotional machinery: it does not give larger weights for larger groups but smaller weights.

You can stare at Figure S.10 as long as you want but still it most probably leaves you unaffected even if it is said to represent the eudemony of 10 000 people. Remember also that in this book eudemony is the ultimate criterion for well-being. Even a minor change in the average eudemony, for instance from 70.0 to 70.1, is equally valuable as a change from meaningless life (0) to flourishing life (100) for a group of ten people. Still, that kind of change is invisible unless the affected people are brought up. A vivid story about ten people saved from misery would surely create intense emotions—something that Figure S.10 will never be able to achieve.

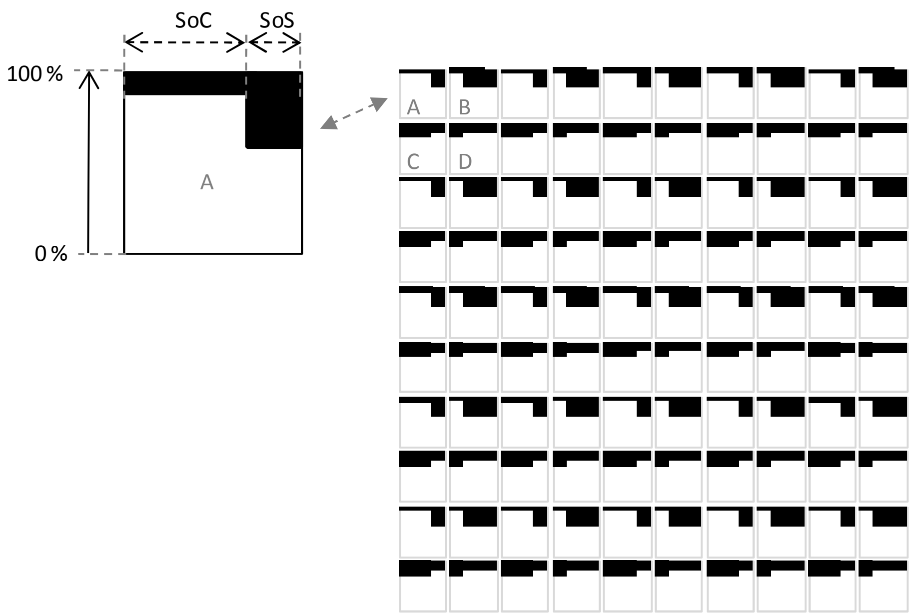

Figure S.9: A community of 100 individuals with 4 different segments (A, B, C, D). The share of white (compared to black) defines the eudemony of each person. The total eudemony of the society is the average share of white = 75 percent.

It is practically impossible to add 100 separate emotions to form an overall picture of the state of 100 people. Instead, what we do in practice is that we pick one person to conduct a closer analysis, usually based on an emotional assessment, as illustrated in Figure S.11. Note also that there are many selection principles: the most similar person to you, the most representative or average person in the society, or the worst person in the society according to some criterion, to name a few. The result of the analysis may depend crucially on this selection principle.

We may arrive at another conclusion based on conscious reasoning. This is the logic of efficient reasoning concerning the merits of communication services: first, we shall assess the situation from the viewpoint of individual users and then we shall make the final assessment based on formal reasoning that is able to take into account the effect of large numbers and network effects.

Figure S.10: A community of 10 000 members with random variations in SoC and SoS. The eudemony of the community is 70 (i.e., the share of white is 70 percent).

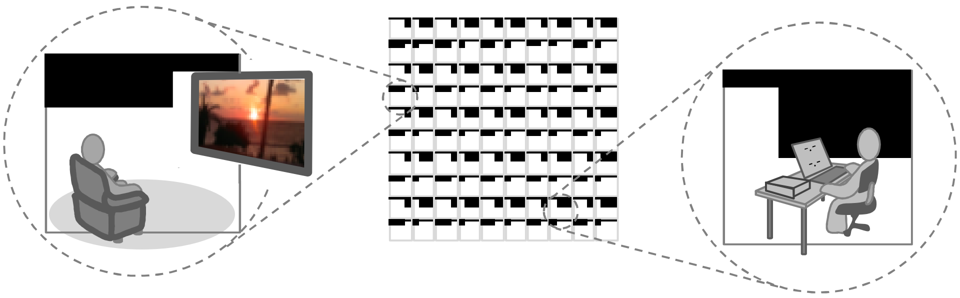

Figure S.11: Two individuals representing a community of 100 people.

Now let us consider a situation in which a change agent wants to improve the well-being of the society depicted in Figure S.9. The change agent is also an observer with a limited observing capability. In particular, it would be difficult for the change agent to assess how much weight a person puts on the sense of significance. Thus, it is likely that the agent observes primarily those aspects that are related to sense of coping and that are easier to observe and measure. Therefore, groups C and D might be more likely objects of observations, because in those groups sense of coping is lower than in groups A and B. In addition, because sense of coping is more important for persons in group C, they likely are louder than persons in group D to express their opinions, and thus, more probable objects of observation.

Whatsoever the selection of the agent will be, the change agent is inclined to use her own intuition to assess how a particular intervention might look like from the perspective of the selected person. Or more accurately, the agent uses her imagination and mirror cells to situate herself in the place of the selected person. Some emotions are likely to emerge, some of them positive and some of them negative. As a result, the first intuition of the desirability of the intervention is made based on this kind of emotional assessment. This is the way the human mind works; and the process is efficient and mostly automated.

An example of communication service

Let us take a more concrete example related to communications services in which 100 users share a common link to the Internet. The available capacity of the link is 100 Mbit/s. Part of the users wants to watch high quality videos while other users use the connection mainly for web browsing and other data applications. The main technical difference is that data applications are able to adjust to varying bit rates whereas video applications require certain bit rate to be useful at all. Thus, video users become satisfied only if a hard capacity requirement is met continuously, otherwise they consider the service useless. On the contrary, the benefit obtained by data users increases smoothly as a function of available capacity.

The specific question to be assessed here is: should the network operator reserve 5 Mbit/s for a user that wants to watch movies or TV? As Figure S.11 illustrates we may consider the situation from the perspective of this particular user. She may want to watch a TV series emotionally important for her. The worst scenario for her is that she is able to watch 20 minutes with perfect quality but then the quality of the video gradually deteriorates in way that the last 5 minutes are impossible to watch. The network operator shall obviously provide guaranteed service for her to avoid this sort of unpleasant experience. The additional capacity required by the video cannot be so important for the data users, most probably they do not notice any change at all. After thinking in this way, it seems that the network operator, indeed, shall reserve bandwidth for this particular user. Almost no doubt about that.

Maybe the conclusion is right, but still the issue is broader and requires a more elaborate analysis. In order to conduct a systematic study we have to make formal assumptions about the perceived benefits created by the applications, for instance:

- For data applications, the average benefit is a logarithmic function of available bit rate as follows: 100 Mbit/s yields maximum benefit (100 percent), 1 Mbit/s yields

50 percent of the maximum benefit, and 10 kbit/s is useless. The group A of data users consists of 80 users.

- In case of video applications 5 Mbit/s is required to produce any benefit at all, but any additional capacity does not add any benefit. Furthermore, the benefit created by the video application is 100 percent for group B and 20 percent for group C (where the same benefit scale is used as with data applications). The size of group B is five users and the size of the group C is 15 users.

Further, we assume that those 80 + 5 + 15 = 100 users represent the active users at a given point of time, which means that the link provides an Internet connection for hundreds of customers, because not all users are active at the same time. Note also that the aim of this simplified model is to illustrate the situation in general and to get provisional insight.

Because the average bit rate available for each user is only 1 Mbit/s, video users are not able to get any useful service at all. Thus, the link capacity is actually shared between 80 data users while all video users remain inactive. This is the Case 1 in Table S.2.

Now if the operator becomes convinced that the video user described above shall get the reserved bandwidth, he may do a simple analysis described in Case 2 of Table S.2. The result seems to support the belief that operator shall implement a system in which video users get bandwidth reservations. The data users likely are unable to recognize any change in the service quality while the particular user becomes much happier. Moreover, the total benefit is increased from 41.94 to 42.49. The overall result seems to be less discriminatory because now at least one video user gets something. The particular user is a kind of representative for the group of video users, creating positive emotions in an outside observer.

However, the analysis must not stop here. If one video user gets special service then most probably other video users want to get a similar service. In the best case, only those video users that really appreciate the videos require the special service. This situation is illustrated in Case 3 in Table S.2. Now the result is even better although data users might notice a small reduction in service quality. The increased satisfaction of five video users more than compensates that small reduction.

Unfortunately, the service provider has limited means to distinguish those video users that put a high value on the video from those that put only a low value but are still willing to watch the videos. Thus, also some users in Group C will likely require special video service. Now, according to model, each member of Group C that requires video service has a negative effect on the total benefit. Finally, if the whole link is reserved for the video users (Case 5), the total benefit is dropped dramatically, because data users do not obtain any benefits.

Table S.2: Evaluation of benefits obtained by distinct groups of customers (A, B, and C).

		Case 1	*Case 2*	*Case 3*	*Case 4*	*Case 5*	*Case 6*
Link capacity (Mbit/s)		100	100	100	100	100	1000
Reservation for video		no	yes	yes	yes	yes	no
Active users:	*A*	80	80	80	80	0	80
	B	0	1	5	5	5	5
	C	0	0	0	5	15	15
Data bit rate (Mbit/s)		1.25	1.19	0.94	0.50	0.00	11.25
Benefit	*A*	0.52	0.52	0.49	0.45	-	0.76
per user	*B*	-	1.00	1.00	1.00	1.00	1.00
	C	-	-	-	0.25	0.25	0.25
	In total	41.94	42.49	44.44	42.17	8.75	69.77

What could the network operator do to solve this dilemma? A special price for a bandwidth reservation is an option. However, because data services are based on flat rate charging, an additional system needed for charging each separate bandwidth reservation probably is economically unfeasible. Besides, any extra price based on usage would likely affect the demand. That might or might not be the aim of the network operator. Moreover, even though some reservations are granted for video users (free of charge), the operator may limit the amount of bandwidth to be used by those reservations. For instance, at most 40 percent of the link capacity can be reserved for video applications. That approach may partly solve the problem, but because of the unpredictable availability of the special video service, many video users remain dissatisfied. Those disappointed customers may have a strong negative effect on the reputation of the network provider, although the network providers just wanted to offer good enough service for almost everyone.

Fortunately, another solution is much better than any approach with special treatment for some users. The network operator shall upgrade the link from 100 to 1000 Mbit/s. The result is presented as Case 6 in Table S.2. Because the average bit rare available for each user is now above 10 Mbit/s, there should not be any problems with video applications even without bandwidth reservations.

The main lessons of this example are:

- Concentration on the needs of an individual person often incites emotions. Emotions are necessary when assessing the desirability of a state of system. However, emotions may shift our attention towards an immediate solution that is clearly beneficial for a particular person or agent.
- The solution when applied to a particular person has almost always some collective effects, that is, more or less desirable effects on other people.
- The collective effect of the solution when applied to one person might be acceptable, whereas the collective effect when the same solution is applied to a realistic group size might be unacceptable.

- In addition, almost any solution (or intervention) leads to some changes in the system behavior. For instance, if video users get bandwidth reservations, data users may require a similar reservation service for them.
- Any special solution to solve the problems of a certain group of people tends to raise fairness issues.

Autopoiesis

The term autopoiesis was first used by Chilean biologists Humberto Maturana and Francisco Varela (1992). They used the term to describe the mechanism that makes living beings autonomous systems. A system is autonomous if it can define the laws that govern its functioning. Later the concept of autopoiesis was utilized in the context of social systems by Niklas Luhmann (see as an introduction Moeller 2006, p. 12 - 14). The term autopoiesis stresses the fact that social systems create and define themselves: while they need all kinds of resources from outside, they also need to reproduce in order to survive. An important aspect of this process is that the system defines and maintains a boundary to its environment. This means that each system has a different environment because every system has a different boundary.

The main point here is that we can see any system from the perspective of autopoiesis, even when the members of the system are not aware of the process of autopoiesis. Typically, any organization interprets its mission as providing some essential services for the society. For instance, the staff of a hospital certainly believes that the purpose of the hospital is to provide health care services, and that mission defines how the hospital operates in reality. That important objective surely justifies many real things and makes hospital important for the other parts of society. Still, there are always processes, rules, and habits that are better understood when considered from the viewpoint of autopoiesis than from the viewpoint of health care.

The objective of this section is to shed some light on this phenomenon by using the long tail model described in more detail in Chapter C. Let us consider a case in which a manager of a department makes numerous smaller and bigger decisions during the everyday management process. We may well assume that the manager makes most of his decision in a way that directly serves the mission of his department. However, now and then he likely is concerned about the future of the department (group, project, firm, organization, etc.). In those cases he may somewhat deviate from the basic rule of serving the true mission of his organization. As a trivial example, the manager may decide to use some money at the end of the year for any imaginable purpose if the money is not anymore available for him at the beginning of the next year. In many other cases, it would be difficult even for the manager himself to notice the bias, for instance, when presenting the results of his own department in a board meeting.

Now let us model the total amount of biased actions during a month by a long tail model with the following parameters:

- N_{50} = 15,
- α = 0.7, and

- β = 100%.

This means that we assume that the 15 most biased decisions represent 50 percent of the total bias during a month. Thousands of small decisions can remain unconscious and undetectable but still add to the total bias. The distribution is illustrated in Figure S.12. Note that all figures and numbers presented here are only for illustrating the phenomenon and reflect primarily my personal intuition.

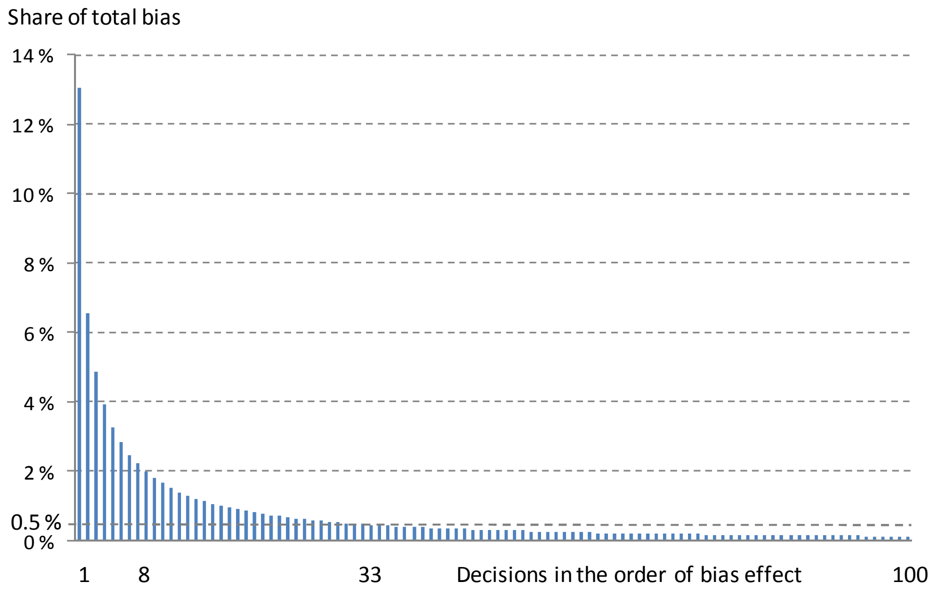

Figure S.12: Long tail distribution of bias effects.

Now we can discern four types of decision made by the person under study:

1. Biased decisions that are observable both by the decision maker and by an outsider observer.
2. Biased decisions that are in principle detectable by the person. However, the person has to consciously observe his or her own behavior and be as objective as possible in order to detect the bias.
3. Biased decisions that are not detectable because the bias is so small that it is concealed by all kinds of noise.
4. Truly unbiased decisions.

We can use the long tail distribution to assess the share of these types of decision. Yet we are not primarily interested in the number of decisions in each group but in the share of bias all actions in a group generate together. Thus, the fourth group is irrelevant here. We can set limits for the observability of bias that leads to the two classes of observations:

- For easily observable decisions: 2 percent of the total bias during the month.
- For decisions that are hard but still possible to detect: 0.5 percent of the total bias during the month.

According to the long tail model, the eight most biased decisions belong to the first group while the next 25 decisions belong to the second group of decisions. The shares of total bias for groups 1 and 2 are 39 percent and 24 percent, respectively, as shown in Figure S.13.

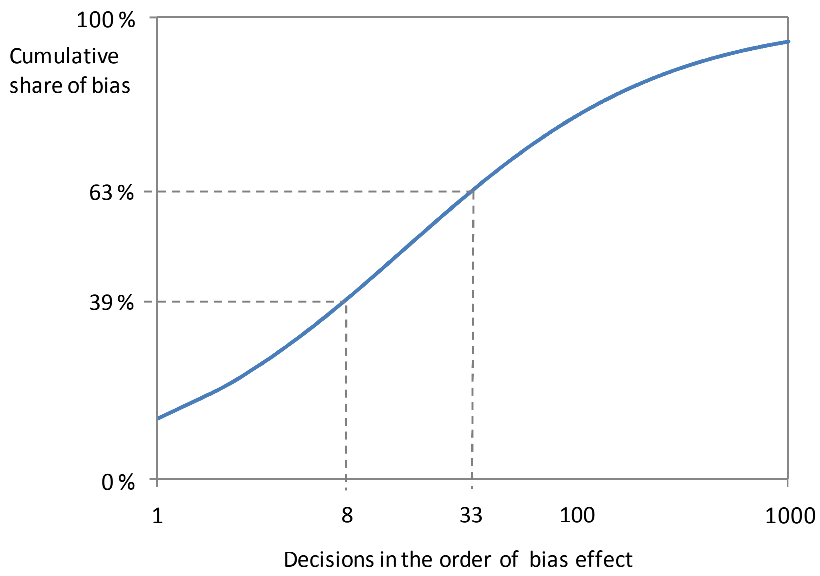

Figure S.13: Cumulative effect of bias during a month.

It would be almost impossible to measure the bias in reality or to make any scientific, controlled experiments. It might be that less than 15 decisions during a month cover a majority of the bias. Still my feeling is that small unconscious decisions together are relatively important. Think, for instance, of all the choices of words when a person tells something about his organization even when the object of a discussion is seemingly neutral. Besides, other signifiers than words may have a momentous effect even when are not aware of them.

An amazing example of this phenomenon is presented by Malcolm Gladwell (2000, p. 74 - 77). According to a carefully designed study made in Syracuse University the positive facial expression of a news anchor had a noticeable effect on the popularity of Ronald Reagan in 1984 presidential election. Those voters that had watched that particular channel were significantly more likely to vote Reagan instead of the other candidate (Walter Mondale).The

TV channel and the anchor, of course, disputed the results of the study. A similar study with similar results was conducted during the next election in 1988.

What is the relevance of this anecdote in the context of autopoiesis? The phenomenon under consideration is an organization that survives after its original purpose or mission is already outdated, even when a considerable amount of members in the organization has been changed. There seems to be a momentum that keeps the organization going without any clear decision by any individual person. Some of the decisions might indeed be easily detectable. The leader of an organization may make some conscious decisions with the main aim to ensure the continuation of the organization, because that also serves the selfish interests of the leader. However, if that were the whole picture we would not need the concept of autopoiesis, because the selfishness of the leader is enough to explain the nature of the process.

In general, if an organization is managed only by means of conscious decisions made by individual human agents, it could be enough to observe only those individuals that make the majority of decisions. That is not necessarily the case, because a great majority of what we are doing is controlled by unconscious automated processes. Many emotions also are highly contagious. This means that those small biases that increase the probability of the survival of the organization may proliferate inside the organization. This may happen even if those small biases are against the explicit mission of the organization and against the short-term benefit of individual members of the organization.

Communication

This section provides a couple of curious viewpoints on communication. You certainly have a lot of experience on communication, as you perform numerous actions of communication every day with your all kinds of people. Furthermore, you might have learned something about the principles of communication during your studies. However, communication is so important for you as a communications ecosystem expert that it is useful to develop your ability to consider it from several perspectives, and even question some common opinions.

The first special perspective is offered by Niklas Luhmann. His far-reaching theory of social systems is thoroughly presented in Luhmann (1995). If you were not interested in studying sociology and in reading demanding text, I would recommend books that explain more concisely the main aspects of Luhmann's theory, for instance, Moeller (2006). Then if you become interested in Luhmann's ideas, you may continue with some of his shorter books, like *Ecological communication*, *The reality of mass media*, or *Love as passion – the codification of intimacy*. Those books might be used for understanding some aspects of the communications ecosystem.

As a result of the evolutionary process depicted in Figure S.1

> **structural coupling**, a state in which two systems shape the environment of the other in a way that both depend on each other for continuing their autopoiesis and increasing their structural complexity,

emerges between brain as a biological system, mind as a psychic system, and society as a communication system (Moeller 2006, p. 18 - 20). From this perspective mind is an intermediate entity between the processes taking place in the brain and the communication within the society. Mind can be irritated from both bodily events and communication. In the framework of Figure H.1, perception includes both physical sensations and communication with external world. They also are deeply intertwined: internal pain can be interpreted as part of a discussion with your own body while a cruel sentence uttered by another person may create a physical pain.

This deep structural coupling between mind and society means also that the mind cannot develop without an extensive interaction with society; our mind is not just a product of our genes but also even more a product of the society. This co-evolution of brain and society explains some patterns of altruistic behavior of individuals, because mind is, in a certain sense, partly possessed by the society. It is important to notice, particularly from the viewpoint of a communications ecosystem expert, that communication is in the core of this process.

Any activity that disturbs this aspect of communication is potentially harmful for the functioning of the society regardless of the possible merits of the activity from other viewpoints including entertaining and business. For instance, some forms of mass media make business primarily by inciting emotions that a normally part of personal communication within a small group of people. It is extremely difficult to assess how the society changes and whether the changes are positive or negative.

Niklas Luhmann argues in *The Reality of the Mass Media* (1996, p. 65) that

> “Since the mass media have generated a background reality which can be taken as a starting point, one can take off from there and create a profile for oneself by expressing opinions, how one sees the future, demonstrating preferences etc.”

Thus, the social function of the mass media is in the memory generated by it. From this perspective, the role of mass media is to provide a starting point for personal communication. So, do we watch TV just to update the content in our memory as regards the current state of our environment? If yes, why do people then watch old TV series from foreign countries? The answer probably shall include both the pure entertainment value and the need to be aware of the same information as other members in the society, particularly your closest friends. These aspects have some consequences for benefit modeling: watching TV may provide in addition to an immediate benefit, such as pleasure or excitement, social capital. Social capital as usually depends heavily on the other people sharing the same experiences, that is, there is a positive network effect. It might be that social media is to some extent replacing mass media in this task of creating a common memory.

We shall also consider the negative sides of modern communication. It is often claimed that the communality is now weaker than in the earlier societies. What could that mean in reality, if true? Are there more

> **free riders**, people who take advantage of a public good, or other collectively funded benefit, while avoiding any personal cost, or evading personal contributions to collective funding?

Because society is essentially communication, it seems natural to assume that some part of communication is the reason for increasing selfishness, for instance, economic jargon tends to assume and even promote selfish behavior. If everything is measured in money and everyone, is free to seek his or her own wealth, who will take care of the common good? You may consider that that is the responsibility of society as a whole, not the responsibility of any separate part of the society. Nevertheless, it is important to keep in mind that without suppressing the power of selfishness and greediness, the current omnipotent technology and economy may lead to a severe global tragedy of commons (see also Luhmann 1989).

Finally, some words about a special element of communication: intimate relationships. As to this curious topic, there certainly are multitudinous opinions. Here I cite, once more, Niklas Luhmann (1998, p. 36):

> "Appearing in the other's world and being able to act accordingly" is something which has to be reactualized continuously. This means that the actor has to make himself observable as someone who goes beyond the normal bounds of his habits and interests. Wanting this must not, in turn, become reduced to a habit like expecting a greeting, a present, or a goodbye kiss; it has to be repeated without assuming the qualities of repetition; or – since this almost invariably fails – at least this must be understood to be its intention."

This is one of the challenges of communicating about love, obviously present also in the realm of social media. Actions of communication must go beyond expected patterns in order to demonstrate the extraordinariness of the relationship, but any action tends to become expected soon. The continuous expectation of exceeding expectations leads inevitably to a collapse. This remark is as valid with love as it is in the context of business or reality-TV series.

Ant colony as an example of communication

Where Luhmann's reflections might be useful to organize our thoughts about the nature of communication in a systematic manner, the other example rather stimulates our thinking. Whether the example belongs to the field of communication or not, is a matter of discussion. Whatever is your opinion, at least it might be useful to think the following example in the light of Luhmann's system.

A part of Douglas Hofstadter's (1999, p. 315) story about Aunt Hilary goes as follows:

> "*Anteater*: Actually, some trails contain information in coded form. If you know the system, you can read what they're saying just like a book.
>
> *Achilles*: Remarkable. And can you communicate back to them?
>
> *Anteater*: Without any trouble at all. That's how Aunt Hilary and I have conversations for hours. I take stick and draw trails in the moist ground, and watch the ants follow my trails."

In this story, Aunt Hilary is the name for the ant colony Anteater is communicating with. Of course, Achilles and Anteater are purely fictitious characters, and the story is, well, just a story.

Still, an interesting mental exercise would be to make a comparison between discussing with an ant colony and discussing with a friend via text messages. You may interrupt the regular behavior of an ant colony, follow how it reacts, make your interpretation about the purpose of the reaction, and finally go on in the discussion by performing another action. You may as well interrupt the regular behavior of your friend by means of text messages, follow how he reacts, interpret his reply, and send another message.

Some twenty years ago, an ant colony found the wastebasket in my kitchen. I discussed, or rather quarreled, with the colony for several days. I even had some amplifiers to make my point: I used a vacuum cleaner to remove the ants and waterproof silicon to fill small holes in the wall of our apartment. Finally, I won the debate, although the ant colony probably did not care whether they won or not. I can imagine that event as a conversation with an ant colony. Anyway, I did not try to discuss with any individual ant. And that is the theme Hofstadter was illustrating with the ant colony story. He (through the characters in the story) claims that communication does not require conscious actors to make conscious decisions. The third character, Tortoise, even argues that an ant may correspond to a neuron in the brain. We can hardly think an individual neuron as an intelligent actor, although a brain consisting of a myriad of neurons sometimes is able to demonstrate intelligence.

That is a vivid metaphor, and surely provides a promising viewpoint. Still, someone may maintain that there cannot be any true communication without two conscious minds. This issue seems to relate to the difference between intentions of conscious mind and the appearance of purpose that seems to emerge as a result of evolution. Those two events are sometimes very difficult to discern. Can we communicate with a purpose created during an evolutionary process? It might be useful to think that we can.

Maybe you can imagine communicating with an ant, but not with a colony. Then if you think about the situation more closely, it makes some sense to think about communicating with a colony or with an organization in general. What is the fundamental difference between communication with an ant colony and communicating with a modern service provider? Still you may think that a discussion with an organization consists of smaller events of communication with people. Even that is not always true, because part of the communication has often been automated. Still you may have an urgent need to get your message through the boundary of the organization in order to solve your problem. You are not so much concerned with persons or automatons you are directly interacting with, but how the organization is reacting as a whole. That process might be called communication.

Table S.3 shows the standpoint of this book to the question: what kinds of interactive events shall we consider communication? I am sure that I can communicate with many human organizations (such as tax bureau) and with some animals (such as a dog). Still, I would not call the physical reactions towards a detrimental microbe inside my body as communication. In contrast, we might consider consecutive actions with an ant colony or with a large group of microbes as communication, but I am not sure whether that is useful extension of the term or not.

Table S.3: Communication between different kinds of entities (a tentative assessment).

	Actor 2					
Actor 1	*Conscious mind*	*Human organization*	*Other living organism*	*Non-human organization*	*Artifact or device*	*Other entity*
Conscious mind	yes	yes	yes	perhaps	perhaps no	no
Human organization		yes	perhaps	perhaps	perhaps no	no
Other living organism			yes	perhaps no	no	no
Non-human organization				perhaps no	no	no
Artifact					perhaps	no
Other non-living entity						no

What is clear for me is that an action with a non-living entity, like a rock, is something other than communication. If someone is tossing me a rock, it might well be an act of communication with the other person, but not with the rock. A harder question is: what is happening when a person interacts with complex device, such as a mobile phone; particularly when he tries to understand its logic in order to be able to manipulate it? For example, I have had encountered this sort of problem when I tried to create a new favorite place in a navigator application (see the use case described in Chapter U). Did that event belong below the concept of communication, and if yes, did I communicate with the device itself or with the designers of the device? I tend to think that typically the person tries to communicate with the designers but ends up interacting with the stubborn artifact. In this type of case, effective communication can occur only when the user contacts an individual person able to give good advice.

Human organizations are similar to human individuals: they can communicate with each other and with individual persons. It is somewhat harder to image that a human organization, such as the bureau of animal protection, genuinely communicates with an animal. Instead, organizations prefer to communicate with a person that is able to affect the life of the animal. Still, there are cases in which communication might be a decent term to illustrate a complex interaction between a human organization and an animal. For instance, a voluntary organization may try to save a big whale that is stuck on the beach and is not able return to the sea.

As to the classification of events, opinions may vary greatly. In the technical domain, particularly in IT and networking sectors, there is a tradition to apply human-oriented terms in a pure technical context. Engineers may say that network nodes communicate with each other by sending control messages. I would prefer not to use term communication, but rather say that the nodes are interacting by means of control messages.

Lessons for CEE

Becoming a communications ecosystem expert is a long journey. This book provides some instruments for coping with some of the challenges. You may select between many directions and on each of them, you need much deeper insight in the main issues of different areas, each of which also form a social system with their own specialists.

Although this is the last chapter of this book, I would not like to make any final summary—besides Chapter I already gave a summary of the main lessons in the format of the seven rules for CEE. Instead of writing a summary of everything discussed in this chapter or in the whole book, I would encourage you to do something else. If you have learned something important, please express your opinion on the next page in Figure S.14 and in Table S.4. The justification for this open ending format is that due to the nature of this book, you have to form your own summary that reflects your background, preferences, objectives, and plans. In order to make the ideas presented in this book applicable during your career it is important to draw a summary about what you have learned. Only what serves your own honest belief about the purpose of life is worth pursuing.

Figure S.14: The core of communications ecosystem in your mind—please draw!

Table S.4: Fundamental purposes: please express your own opinion.

Topic	*Your opinion*
What is the fundamental purpose of communications ecosystems?	
What is the purpose of technology in general?	
What is the purpose of your life?	

Book recommendations

H. Maturana, F. Varela, 1992, *The Tree of Knowledge*, Boston, MA: Shambhala Publications.

> A clearly written and illustrated guide to understand how such a complex entity as human being has evolved. This kind of insight into the biological roots of humans provides crucial help when we try to understand the behavior of individuals and particularly the organization of human communities.

D. Meadows, 2008, *Thinking in Systems* (edited by D. Wright), White River Junction, Vermont: Chelsea Green Publishing.

> This is an excellent introductory book to system thinking. I completely agree with the advices given by Donella Meadows in the seventh chapter of her book: from "Get the beat of the system" to "Don't erode the goal of goodness." A communications

ecosystem expert has to have personal experience of the ecosystems to be studied, and most importantly, the expert must remember and honor the ultimate goal of the effort.

H. G. Moeller, 2006, *Luhmann Explained*, Chicago, Illinois: Open Court.

I my opinion, Niklas Luhmann was one of greatest thinkers during the last century. However, in this case I would recommend starting with a book explaining the ideas of an author instead of the original books. Communications ecosystems essentially consist of social systems. From that perspective, the ideas and concepts proposed and studied by Luhmann can be highly valuable.

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