Concurrent, Communication and Computation
A position paper

L. Bernardinello, F. Cardone and L. Pomello
Università di Milano-Bicocca — DISCo

Now is the time to shift our view of computers from communications medium to negotiation medium, from knowledge processing to interest processing.

Carl Adam Petri

The experimental slant that characterizes many current research programs in computer science is questioning the essence of computing as an activity performed by devices that operate mechanically on finite, discrete configurations, according to Turing’s well-known and path-breaking analysis. There is the need for an analysis of computation based on new metaphors, that take into account the increased generality in which computational notions afford analysis and modeling tools. The metaphor of computation as communication is one such metaphor, and one that is not new, see for example the recent use of it in [Wegner, 1997; Milner, 2006]. Even when studying sequential systems, it is often illuminating to consider the System jointly with its Environment and to focus on their patterns of interaction. This happens, in particular, when specifications are regarded as contracts in the design of both hardware and software components.

In this paper we take up this metaphor by discussing some of its instances in order to convey an idea of its scope. We do not, however, suggest redefining computation in terms of communication, even though this may reasonably be held as a philosophical thesis on the nature of computation. Instead, we try to isolate a few leading themes of a research program centered on the use of computer as a “general medium for strictly organized information flow” [Petri, 1976].

1 From fair division to debates, and beyond

Our discussion is of necessity only tentative, aiming at delimiting an area of investigation which is new and whose problems still need to be formulated systematically, although we shall see later how it relates to more or less recent research. Roughly, this area is characterized by:

— an investigation of coordination (or organization) problems among persons,
— whose solutions are formulated in terms of **procedures**, often described in natural language terms, which have therefore a certain amount of vagueness, but do not involve arbitrarily large amounts of human effort or resources, like space and time,
— whose properties can nevertheless be stated and proved in a **formal** way.

Our aim is now to demonstrate that such procedures do exist, and actually they have been known for a long time, although only very seldom people have been aware of them. Methodological problems that we leave open in this preliminary account concern, in particular, the sense in which the procedures admit a formal treatment: for the moment we stick to a perhaps naïve understanding of formal as mechanical, along the lines of Holt’s Communication Mechanics [Holt, 1974].

### 1.1 Fair division

The problem of devising a procedure for attaining fair division was originally stated by Steinhaus as follows:

«[…] To divide an object like a cake into two equal parts, we can adopt the old custom of letting one partner cut and the other choose. The advantage of such a procedure is obvious: neither of the partners can object to this division. The first can secure the part due him by dividing the cake into two parts that he considers to be equally valuable; the second can secure at least his due part, by choosing the more valuable part or — if he considers them equally valuable — either part.» [Steinhaus, 1960]

We are interested in this problem as a paradigm of situations where a procedure governs the interactions that take place within a group of persons so that its correctness does not depend on the result but on the way the procedure is designed. In particular, fairness has a procedural definition [Holt and Cardone, 1996]. Observe that [Rawls, 1972, §14] takes fair division as an example of perfect procedural justice, assuming that all the $n$ participants are entitled to an equal amount of the cake. This is so because:

1. there is an independent standard for judging the outcome of the division procedure: this standard says that each of the $n$ participants is entitled to $1/n$-th of the whole cake, and
2. the outcome of the procedure conforms to the pre-existing standard, in that it yields at least that much of the cake for each claimant.

Rather, we tend to see this as an example of **pure** procedural justice, where there is no independent standard to judge the outcome of the procedure. In fact, should we rely upon measurement to assess the fairness of the division procedure, as suggested by point 1, we would essentially appeal to an umpire who guarantees the impartiality by measuring with infinite precision. (A similar problem arises with implementing a fair coin: how is it possible to guarantee that the ratio heads/tails is exactly $\frac{1}{2}$ in the
We do not want to admit the possibility of infinitely precise measurement, and this leads immediately to consider non-transitive similarity relations, which have been studied by Petri and his co-workers as instances of (axiomatic) concurrency relations [Petri, 1977].

1.2 Debates

One objective of the kind of research we are envisaging is to make explicit the often hidden procedural basis of many types of disputes. The first stage of such an investigation tries to extract a system of notions and rules underlying each type of dispute. There are several examples of these:

Robert’s Rules of Order [Robert, 1915]: these underlie (with a normative component) the debates that take place in deliberative assemblies. These rules prescribe, in particular, how motions should be taken up in such assemblies, e.g.: “A question is said to be pending when it has been stated by the chair and has not yet been disposed of either permanently or temporarily. When several questions are pending, the one last stated by the chair, and therefore the one to be first disposed of, is said to be the immediately pending question.” [Robert, 1915, Introduction]. This endows the list of motions in a debate with a well-defined structure which can be formally evaluated from the point of view of its adequacy to achieve fairness in disputes. We are not aware of any result in this area.

The Chatham House Rule of Confidentiality: “When a meeting, or part thereof, is held under the Chatham House Rule, participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed” [Chatham House, 2002]. The motivation for this rule is that “It allows people to speak as individuals, and to express views that may not be those of their organizations, and therefore it encourages free discussion” [ibid.]. The rule has been studied form the point of view of Petri’s communication disciplines [Ferigato and Masera, 2006].

Dialogues: specific rules of communication also underlie the dialogues that have been used as a foundation of logic in the tradition of Lorenzen [Lorenzen, 1961; Barth and Krabbe, 1982]. These dialogues consist of speech acts of Attack and Defense performed alternately by a Proponent and an Opponent. There are rules for each of the logical particles, for example a conjunction ‘A and B’ can be attacked in two ways: by attacking the left conjunct (?L) or the right conjunct (?R). In the first case the defense consists in defending A, in the other case in defending B. Besides, there are procedural rules, like the following:

- Proponent may only assert an atomic formula after Opponent has asserted it,
- if one responds to an attack, this has to be the latest open attack (to which one has not replied yet),
- an attack may be defended at most once,
- an assertion made by Proponent may be attacked at most once.
It turns out that, by changing the procedural rules, the resulting logic changes, so it is important to justify them at an even more basic level. An idea for achieving this consists in keeping track of the complex network of commitments that is created while such dialogues proceed. Managing the creation and destruction of such relations should be related to classical ways of creating and extinguishing obligations, e.g., in the Roman code, *delegatio*, *compensatio* and *confusio*, which give rise to an interesting algebraic calculus.

1.3 Early accounting

The above remarks on a calculus of commitments in dialogues and its relations to commercial law suggest directly to look at the structure of accounting. We only remark that double-entry accounting has a very natural algebraic structure which has been formalized by means of categorical algebra [Katis, Sabadini and Walters, 2008], standard group theory [Ellerman, 1985] and Feynman-like graphs [Braun, 2001]. The latter account makes also evident the relations with early forms of accounting by means of tally-sticks.

2 Related investigations

The work of Petri on formal pragmatics [Petri, 1986] contains several examples pertaining to the area of investigation we are pursuing; actually, most of our examples are part of his Communication Disciplines [Petri, 1976, 1977]. His work in that field is, however, somewhat unsystematic, for example in lacking a model of communication setting the frame of reference for the development of such disciplines.

Some of our examples (especially fair division procedures) suggest analogies with the problems studied by mechanism design: this area of research uses tools from economics and game theory to design interaction rules for economic transactions, for example auctions. It originates from the work of L. Hurwicz.

Observe that, while these analogies point to a possible use of the tools of mechanism design in the formalization of our subject, our research studies situations in which participants have perfect information.

Closer to our aims is the recent proposal of investigating “social software” [Parikh, 2002], where procedures for the orderly and purposeful interaction between persons are constructed and verified by means of formal logical tools.

References


