

ϕ-COLA: TOWARDS A LOGICO-PHYSICAL COORDINATION LANGUAGE

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1. Introduction: The CoLa Coordination Language

The CoLa coordination language [Hi94] is aimed at providing a general platform for the development of applications in the field of distributed artificial intelligence in a massively parallel environment. To achieve maximal functionality and portability, CoLa is embedded in classical programming languages and provides flexible abstraction for purpose of communication between agents. CoLa relies on three fundamental concepts enrooted in a locality principle: *Correspondent*, *Point of View* and *Message*.

The *correspondent* concept is a high level identification abstraction allowing an agent to address other agents in the system. The CoLa *point of view* describes a set of correspondents. It allows a local definition of the social organisation and of the rules governing its different structures. To communicate a certain informational content (*message body*), an agent first specifies the point of view defining its recipients (for example the members of a department), then the *spreader* through which it is emitted (for example Fax, Email,...). Symmetrically, message reception by an agent is first subordinated to the activation of *filters* corresponding to the spreaders, and then to a selection depending on points of view. In fact, the coupling between spreaders and filters determines a communication medium.

2. Towards a logico-physical coordination

The CoLa coordination language allows on one hand to structure a parallel application into different logical entities via points of view, and on the other hand to bind them with different communication media. This approach has the advantage to abstract the application from the physical layer over which it rests and to relieve the programmer from the problems related to resource allocation, task scheduling, etc. However, the absence of physical information and the way of considering agent interaction only through a communication mechanism deprives the application from the most primitive and fundamental coordination schemes [Fe95], [Ge92]:

- in an agent system as in any social system, shared resources (be they but clocks!) are an essential basis for cooperation and coordination between individuals [Po95];
- spatial proximity brings necessarily a capacity to interact, which is itself able to support intensive coordination;
- the capacity for agents to regroup in a confined or restricted space is basic to cooperation. Some social psychology works precisely confirm this fact [St78].

These schemes are actually the grounding of the total coordination efficiency and it is therefore nonsensical to conceive a coordinated system while abstracting from its subtending physical space. So, we hereby suggest that the architectural substratum in which the logical agents are implemented must explicitly show through as a CoLa communication medium.

This implies an extension of the CoLa concepts by fitting the coordination language not only with mechanisms allowing to structure logically the application's entities, but also with tools allowing the logical agents to interact with their physical environment. This may include on one hand the capacity for agents to explore and spy upon the physical underlying platform in order to behave judiciously, and on the other hand to influence it by their logical coordination requirements.

As illustrated by figure 1, the interaction between the logical and physical layers must be double. The intrinsic dynamics of the physical layer (evolution of the number of machines in the network, opening of new high bandwidth connections,...) induces organisational transformations at the logical level, and the

other way round, the logical level's organisational dynamics induces structural transformations of the physical state (dynamic switch networks, agent migration, dynamic shared memory allocation, etc...).

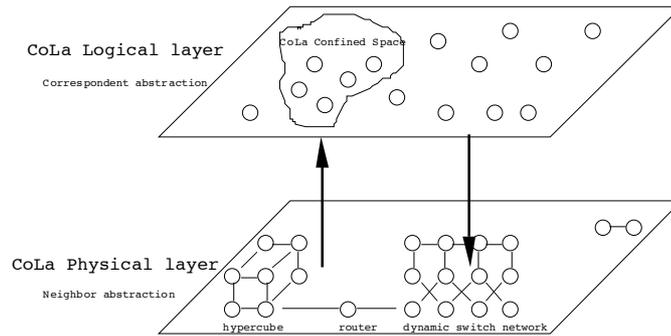


Figure 1. Two CoLa layers

3. ϕ -CoLa : Cooperation between Logical and Physical Layers

The need for cooperation between the logical and physical levels leads us to introduce a certain amount of new concepts in ϕ -CoLa, specifically these are: *Neighbours* and *Confined Space*.

In ϕ -CoLa, the notion of an agent's *Neighbour* designates an agent that can be directly accessed in the physical layer of the first agent. This *Neighbour* is an implicit correspondent in the logical layer ("directly accessible" having different possible semantic meanings, depending on the physical system, for example: "on the same computer", "directly connected over a bus", "in the same address space", "within ten meters of", etc...).

Similarly, the concept of *Confined Space* allows the physical layer to add a communication medium with peculiar features. Such a space can offer access to shared resources (for example a blackboard) or isolate a set of agents from the rest of the system.

In the dynamics of a ϕ -CoLa application, both layers interact through these concepts. In the logical layer, the creation of a confined space can be driven by the fact that the problem to solve needs a high degree of collaboration in a specific subset of agents. Through a request to the physical layer, the application can ask that such a coordination space be made available for a group of agents that need to work with tight physical links. The physical layer then self-organises in order to satisfy the request to the best of its ability. This could lead to the opening of new optical fiber channels, that in turn would reflect on the neighbourhoods and then on the Correspondents, etc...

4. Conclusion

As an extension to the coordination kernel of CoLa, ϕ -CoLa dips coordination in a logico-physical continuum where agents interact and communicate through different, eventually autonomous (that is, fitted with their own exchange and evolution laws), media. Starting from the inseparability of the logical and physical layers of a distributed system, ϕ -CoLa leans on the ability to describe the characteristics of a physical system and the logical-physical world interactions. The generic concepts we put forward here can adapt to heterogeneous physical spaces and open up to a unified coordination between agents of a different nature: logical entities, robots and human beings...

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