



On the Notion of Agent Coordination Context

Andrea Omicini

presented by Alessandro Ricci

DEIS

Università di Bologna – Sede di Cesena



On the Notion of Agent Coordination Context



Outline:

1. Some Reflections on Human Societies
2. Context: An Overview
3. Objects vs. Agents: The Issue of Control
(toward Agent Coordination Context)
4. Subjective vs. Objective Viewpoint
5. Open Issues
6. Lessons Learnt



A First Look back to Human Societies



- Impact of **Environment** as the Main Factor driving the Evolution of Human Societies (*Diamond, 1998*)
 - historical/evolutionary look to human societies
- Environment determines
 - which (kinds of) individuals survive
 - which (kinds of) societies / organisations prevail through resource availability & limitations, necessity
- Short, Medium, Long Term
 - in the short / medium term, **interaction** between individuals / societies and the environment determines their success/failure
 - in the long term, the environment is a **dynamic** and **active** participant in the evolution of individual / societies – the main factor, actually



Does this Holds for Agent Societies, too?



- A Simple Principle of *analogy*
 - several individuals **autonomously** acting in an **unpredictable** and possibly hostile **environment**
 - trying to achieve their own **goals**
 - **interacting** with other individuals
 - cooperating, competing, coordinating
 - according to complex **interdependency** patterns
 - not anthropomorphic principle, anyway
- Historic Sciences may help us understanding the future evolution of agent applications



Humans (Agents) are ...



- situated
 - no way to say that a $H(A)$ is *more intelligent* than another with no respect to the environment where they live
- specializable
 - general purpose "machines" that easily get specialisation according to the environment they live in
 - adaptability is more than learning
- speaking entities
 - language as a tool for representation, not enaction
 - *interaction* is always more complex than communication
- context-aware
 - representing and learning from the environment
 - trying to affect / change the environment for their purposes



Human (Agent) Societies are ...



- open to change
 - culturally "conservative" societies are wiped away
 - social learning
- reactive
 - to environment pressure / changes
 - dynamically evolving organisation
- competitive
 - try to overcome each other
 - grow / disappear according to their success
- non-scalable
 - organisation fits a precise scale, and does not scale up
 - e.g., peer-to-peer organisations scale up to 80-100 individuals, then fail
 - and, a larger number of individuals requires decoupling in the interaction



Human (Agent) Environment



- part of the environment *falls out* of human (society) control
 - physical laws
 - phenomena (environment emerging dynamics)
- part of the environment *falls within* human (society) control
 - controlled change / evolution
 - modelling environment and its dynamics (e.g. cause/effect)
 - requires goal-oriented activity and planning capabilities

does this hold for *agent environments*, too?

- there are non-controllable forces (e.g., the market)
- but we are *the* designers and engineers of the systems

→ modelling / engineering Environments as a main concern:

so how do we model the environment?



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Context as a Conceptual Tool



- From sciences of language (and philosophy, AI)
 - context as a tool to model human / conversational environments
 - enabling interpretation / giving semantics to communication acts
 - basically, modelling the effect of the *environment* on the (whatever) "text"
 - accounting for ***situatedness of interaction / communication***
 - coming to say that we cannot talk of "interaction" without talking about the environment
 - *spatial* context
 - virtual location
 - *temporal* context
 - virtual synchronization, historicization
- context as a conceptual tool to model the (agent) environment



Contexts in Computer Science & Affiliates



- Contexts in Logic
 - CtxLP
 - the dynamic evolution of the axiom set representing the current context determines the truth value of a logic formula
 - the proof of a goal may dynamically change the current context of proof
- Contexts in AI
 - Giunchiglia & friends
 - "Context" conference since 1997
- Contexts in Programming Languages
 - e.g. scope
- Contexts in the path from OOP to POP (Post OOP: AOP, SOP,...):
 - trying to overcome OO limits in modelling not functional aspects, inter-objects dependencies, environmental properties that are typically context issues



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Control in OO Systems (1)



- Control flows along with data in OO systems
 - "coupling" in the very notion of method invocation as the reification of message passing – one single way to "move" control along a OO system
 - this simplify the design at the small scale – all in my designer's head
 - but makes it an effort to design at the large scale, and a mess to do it in complex environments – like any sort of coupling
- Designer as a *central control authority*
 - control is out of objects, flows through them, crosses their boundaries
 - out – in, and back
 - "control" is the main issue – *design* is designing control in OO systems
 - managing control on the large scale requires engineering discipline
 - the *control king*



Control in OO Systems (2)



- *Interface* notion as a tool for OO software engineering
 - constraining inter-objects interaction (control and data passing)
 - a complete description of the environment at design time
 - interfaces fully describe objects
 - as far as their observable behaviour is concerned
 - in front of the "control king" out of them
 - and separate them from the outside
 - decoupling
 - many nice engineering properties
- Latest developments on this subject...
 - objects and brokers in distributed environments
 - IDL, *inspectable* interfaces...



Control in Agent Systems



- Agent systems are not control-driven
 - responsibility, task
- Agents are independent *loci* of control
 - agent's task drive the control
 - control and data are decoupled, data do not flow with control
 - this is nice *per se*
 - control does not cross the agent boundaries
 - at least, it does not enter agents
 - data / information do – flow in and out
- Agents are the "control kings"
 - so, in large complex systems, they do need a disciplined environment
 - what is the notion corresponding to object interface?



Toward Agent Coordination Context



- Agents *have not interfaces*
 - agents are autonomous and basically pro-active
 - you cannot *invoke* one agent
 - control is *within* agents, does not flow in from the outside
- They need a corresponding notion, instead
 - to make their management of control effective
 - to model the environment, the society and inter-agent aspects in general (other agents, resources, threats, services, norms, social rules...)
- A principled design requires environment description
 - either known at design time, or inspectable at run-time

→ **Agent (Coordination) Context** (abstraction and tool)

- expected to play the same role as the notion of object interface in object system
- and some more – since agents do not represent the only sort in agent environments
- as an interface, a ***boundary description*** – but from inside out



Bounded Coordination Context



- **control room** metaphor
 - making agent's life simple
- bounded interaction
 - bounded inputs
 - *lights* (discrete input – e.g., looking for events)
 - *screens* (continuous input – e.g. looking for states, or hearing)
 - bounded outputs
 - *buttons* (discrete output – e.g., sending signals)
 - *microphones* (continuous input – e.g. showing some state, or speaking)
- A bounded coordination context should be
 - prescriptive
 - known or inspectable,
 - possibly modifiable
 - by managers
 - by agents
 - protocols for negotiating / paying for new boundaries?



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The Subjective Viewpoint



- The environment *from the agent's viewpoint*
 - what is my current context of interaction?
 - spatial / temporal contexts

→ Context as a modelling tool

- a framework enabling to enable agents to model the environment where they live, interact, and communicate
 - whatever is its formal definition
- context representation language
 - state and dynamics

→ Context as an engineering tool

- the agent: “what is happening around me ? how can my own behaviour affect the environment, what can / will I do?”
- the designer: “how will I design my agents and make them act within and react to the agent environment?”
 - agents thinking about (interaction, coordination) contexts / acting on contexts



The Objective Viewpoint



- The environment *from the designer/engineer viewpoint*
 - which interactions are going on
 - in time and space
- Context as a modelling tool
 - a framework to express how the environment affects agents living, (inter)acting and communicating
 - context representation language
- Context as an engineering tool
 - allowing engineers to encapsulate rules governing applications built as agent systems, mediating agent interactions, and possibly affecting them to drive the global application behaviour (**coordination**)
 - allowing agents to change their environment
 - configurable context
 - mediating between application and host needs



Contexts and Infrastructures



what about agent coordination contexts in development and deployment stage?

embodied in *Agent Coordination Infrastructures*

- modelled in term of coordination context
- providing services / tools to manage agent interaction and coordination and first class issues

Example: TuCSoN Agent Coordination Infrastructure

- enabling (mobile) agent interaction and coordination
- open-source java-based technology



Prescriptive Coordination



- agent coordination infrastructure to embody contexts at the *deployment stage*
- a way to specify *and constrain* at runtime agent interaction space
- enforcing social/environmental rules while promoting agent autonomy
 - agents are free to deliberate and act according to their goals
 - no constraints on agent model, no runtime actions on their whatever body or mind

agent behaviour is ruled not acting on agents,
but ruling the context where agents act

- so *inspectable* contexts, please!
 - so *evolvable/adaptable* contexts, please!
 - toward *social order engineering*
- (Castelfranchi, ESAW 2000)



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Open Issues (1)



- **Context Representation** [Ziemke 1997, Embodiment and Context]
 - How to support situated communication?
 - Is *communication* primitive, or is *action*?
[Gardenfors 1997, The Pragmatic Role of Modality in Natural Language]
 - Is *context* a viable notion for (agent) environment modelling/representation?
 - Does situatedness cope well with symbolic representation of the environment?
[Brooks 1999, Cambrian Intelligence]
 - **Openness, Security & Prescriptive Coordination**
 - Open agent applications / systems?
 - Do we share a notion of openness?
 - Do we share a notion of application / system?
 - Security as a coordination problem?
[Cremonini 1999, Multi-Agent Systems on the Internet: Extending the Scope of Coordination towards Security and Topology]
- *Prescriptive Coordination to enforce properties while preserving autonomy*



Open Issues (2)



- **Economy Issues in Agent/Environment Interaction**
 - What is the cost of communication?
 - Information has a cost, *Interaction too*
 - What is the (added) value of coordination?
 - How do we support / represent the economy view of the environment?
 - Economy context?
- **Embodying Contexts: Agent Coordination Infrastructure**
 - Context as a ***Social Construct***?
 - [Akman 2000, Rethinking Context as a Social Construct]
 - How/where do we embody environment properties?
 - How do we enforce prescriptive coordination?



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Lessons Learnt



- The study of human (society) evolution tells us...
 - that we cannot even *understand* the evolution of individuals and groups in any non-trivial setting without explicitly taking the *environment* into account
- The notion of context...
 - is extensively used in several fields to model the effect of the environment
- The reverse-control issue in OO / Agent systems...
 - calls for a new agent notion *dual* to the object interface one
 - and **agent (coordination) context** could do the trick
- For contexts, we need...
 - representation ontologies, abstractions, and languages
 - run time abstractions and support
 - methodologies, tools and infrastructures
- ... to model and engineer environments and societies in agent systems as first-class entities