



Social Issues in the Construction of Agent Systems

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Outline of this Tutorial

- The Many Ways of Complexity
 - The Role of Agents and Agent Systems
 - Social Issues: Interaction and Coordination
 - Building Agent Societies
-
- Possibly avoiding technicalities...
 - ... and within two academic hours :)



Social Issues in the Construction of Agent Systems

Part I



- The Many Ways of Complexity
- The Role of Agents and Agent Systems
- Social Issues: Interaction and Coordination
- Building Agent Societies



Looking for Complex Systems

- We are
 - Complex Biological Systems
 - Living in Complex Social Settings
- Looking at Scientific Results from
 - Social / Historical Sciences
 - Biology
- To Find Applicable
 - Metaphors
 - Structures
 - Evolutionary Patterns



Complexity in Human Societies

- Jared Diamond. *Guns, Germs, and Steel: The Fates of Human Societies*. W.W. Norton & Company, March 1997.
- Human Societies not Easy to Formalise...
- Talking about (R)evolution...
 - the role of change and competition
- No need of any Antropomorphic Principle
 - weak analogy is enough



Look at Humans as Individuals

- Specializable
 - general purpose “machines” that easily get specialisation according to the environment they live in
 - Situated
 - no way to say that a human is *more intelligent* than another disregarding the environment where they live
- > Adaptability is more than Learning
- individuals as results of complex patterns of evolution



Also, Humans are...

- Social Entities
 - social organisation as a major achievement
 - in particular, speaking entities
 - language as a tool for representation, not enaction
- > *Interaction* is always more Complex than Communication
 - > and communication is far to be language only
- Context-aware
 - context is more than social context
 - representing the environment, and learning from it
 - trying to affect / change the environment for their purposes



A Look at Human Societies

- Open to Change
 - culturally “conservative” societies are wiped away
 - social culture, social learning
 - the role of artifacts
- Reactive
 - to environment pressure / changes
 - adaptive
- Work as Dynamically Evolving Organisations



Also, Human Societies are ...

- Competitive
 - try to overcome each other
 - grow / disappear according to their success
 - Non-scalable in Structure
 - 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
- > Prescriptive Enforcement of Norms
- > Written Norms



Human Societies in Context

- Impact of Environment as the Main Factor driving the Evolution of Human Societies
 - historical/evolutionary look at human societies
- Environment Determines
 - which (kinds of) individuals survive
 - which (kinds of) societies / organisations prevail through resource availability & limitations, necessity



A Look at Human Environment

- Part of the Environment *Falls Out of* Human (Society) Control
 - physical laws
 - phenomena
 - as the 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



Complexity in Biological Systems

- John Maynard Smith and Eörs Szathmáry. *The Origins of Life: From the Birth of Life to the Origins of Language*. Oxford University Press, May 1999
- ✓ Ok, Sorry, it is a *vulgata*
 - ✓ but is perfectly OK for computer people ★
- ✓ Complexity in Biological Systems
 - ✓ far more older than social systems...
 - ✓ evolution even more unintelligible



The Evolution of Living Systems

- Transitions in Terms of
 - organisation
 - information
 - Implicit vs. Explicit Representation
 - Self-representation
- Adaptability as a Feature of Species
 - reproduction and errors



Social Issues in the Construction of Agent Systems

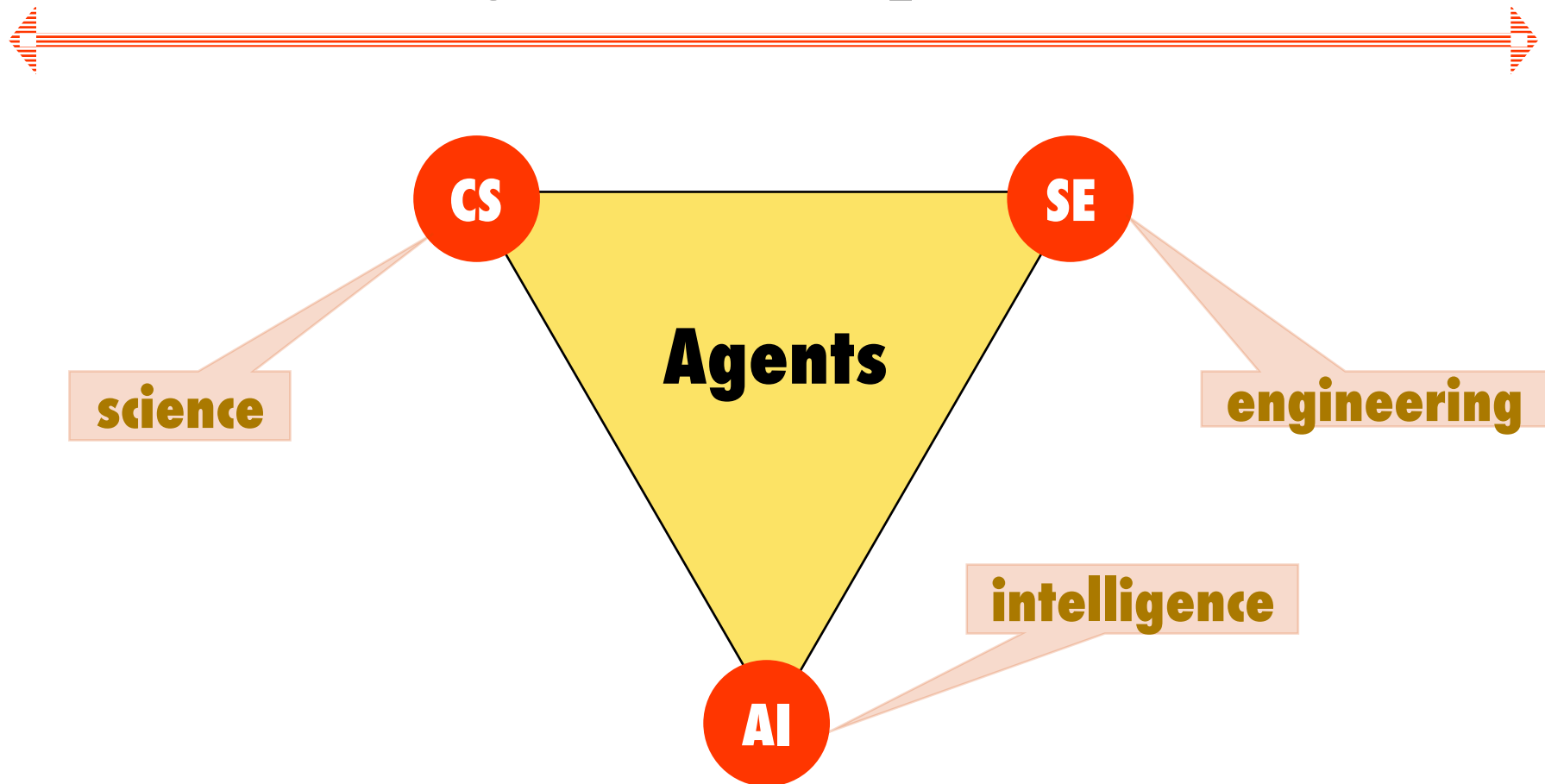
Part II



- The Many Ways of Complexity
- The Role of Agents and Agent Systems
- Social Issues: Interaction and Coordination
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The Triangle of Computer Research





Agents in AI

- Obviously Intelligent
 - some architecture like BDI
- Communicative
 - some ACL like FIPA one
- Coarse-grained
 - sorts of huge mammoths...
- Yeah, Situated, but...
 - gosh, we AI people already had enough of this, thanks...



Agents in CS

- Mobile?
 - from the P&D people
- Automate some boring task
 - like network management
- Independent *loci* of control
 - which is great to abstract away from control

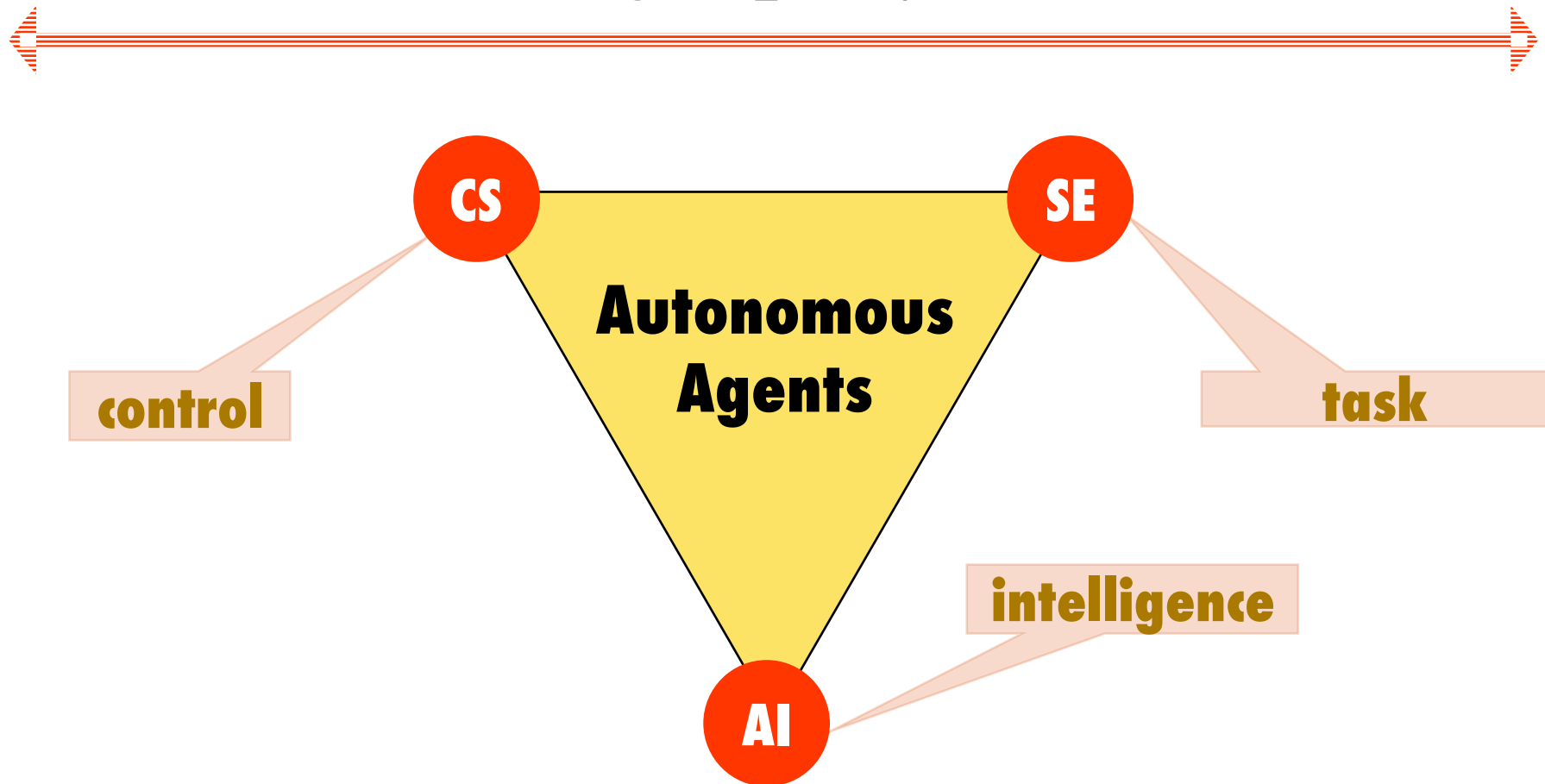


Agents in SE

- ... do they exist? ☺
- AOSE
 - Agent-Oriented Software Engineering
 - Agents Take Charge of Tasks
 - task-oriented engineering
 - individual and social tasks
 - Agents, Societies and Environment
 - as fundamental, first class SE abstractions
 - to model and engineer complex systems
- Agent Technologies and Methodologies



Picking Up my Bests





... that is...



- Agents are
 - independent loci of control
 - level of mechanism
 - in charge of a task that they pursue autonomously
 - task as a metaphor to drive control
 - with a (possibly intelligent) deliberative capability
 - intelligence as a tool to accomplish tasks



A Look at Agents as Individuals

- Specializable
 - general purpose “machines” that easily get specialisation according to the environment they live in
- Situated
 - no way to say that an agent is *more intelligent* than another disregarding the environment where they live
- > Adaptability is more than Learning
 - individuals as results of complex patterns of ... what ?



Also, Agents are...

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 - > Written Norms?



Agent Societies in Context

- What is Context for Agents and Agent Societies?
- What is the Impact of Environment on the Evolution of Agent Societies?
 - evolutionary look at agent societies?
- May Environment Determine
 - which (kinds of) agents survive?
 - which (kinds of) agent societies / organisations prevail?
through resource availability & limitations, necessity



A Look at Agent Environment

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 - physical laws ?
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- Part of the Environment *Falls Within* Agent (Society) Control
 - controlled change / evolution
 - modelling environment and its dynamics (e.g. cause/effect)
 - requires goal-oriented activity and planning capabilities
- Part of the Environment *Falls Out of* Agent (Society) Control
- but *within* Human (Engineer) Control
 - we may act as *gods* in agent societies
 - changing the environment according to our understanding, needs and desires



Social Issues in the Construction of Agent Systems

Part III

- The Many Ways of Complexity
- The Role of Agents and Agent Systems
- Social Issues: Interaction and Coordination
- Building Agent Societies



Premise to any Social Action...

- ... is Interaction between Individuals
 - long before communication
 - which is not even strictly needed
- Society vs. Collective
 - social intention, or understanding
 - we do not go further inside this
 - Falcone's Tutorial at AAMAS 2002
 - we go collective, then specialize social



A Constructive Viewpoint over Social Issues

- A Constructive Viewpoint over Interaction
 - ✓ building the interaction space
 - > enabling models and technologies
 - ✓ governing the interaction space
 - > coordination models and technologies
- Social Issues as Agent Coordination Issues



Coordination



- Multidisciplinary Issue
 - today critical everywhere
- Controversial Definitions
 - between different areas
 - but even within the same area...
- The term “Coordination” generally Applies
 - whenever a system of any sort is amenable of a description in term of a multiplicity of interacting entities



What is Coordination?

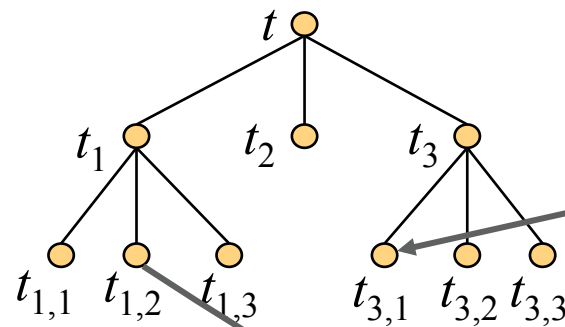
- Everybody knows, nobody agrees
 - “This is not *coordination*”
- Robotics, Software Engineering, Multi-Agent Systems, Programming Languages, ...
- Social Sciences, Economy, Biology, ...



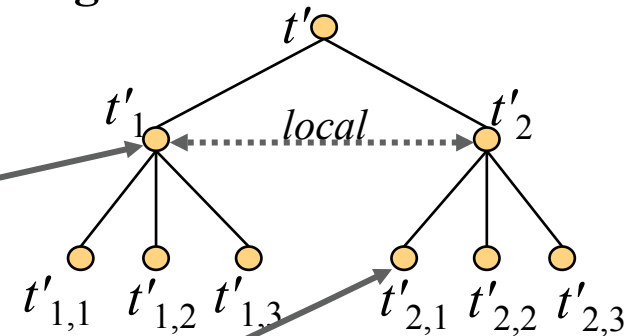
Coordination: Definition 1

Coordination: Management of Dependencies (Malone & Crowston)

Agent 1



Agent 2



type A

type B



Coordination: Definition 1 (b)

- Ontology
 - “coordinables”
 - agents / processes
 - objects of coordination
 - tasks/ goals/ activities/...
 - taxonomy of dependencies
 - shared resources, producer/consumer etc.
 - set of coordination actions / primitives / transactions
 - synchronisation, resource selection etc.
 - out, in, rd



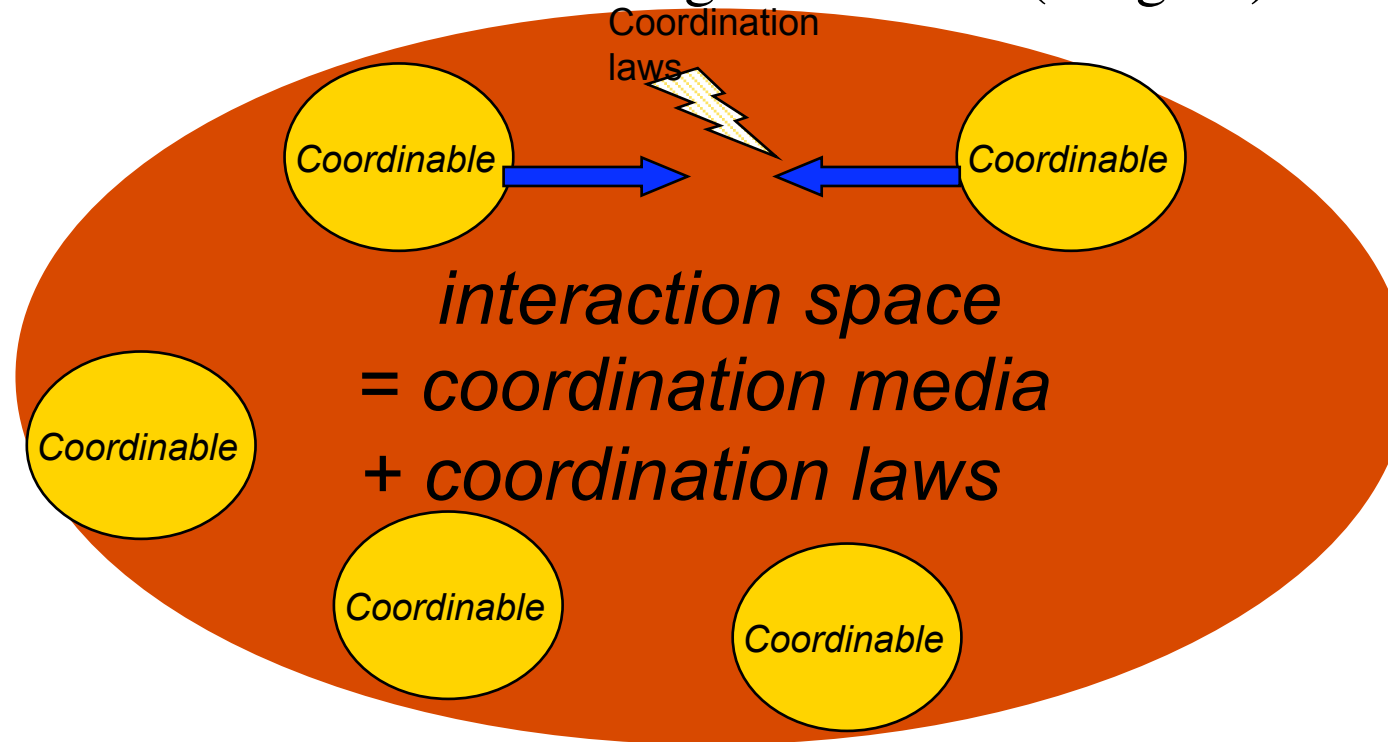
Coordination: Definition 1 (c)

- Coordination Process
 - dependency **detection**: which dependencies are present
 - management **decision**: which coordination actions/primitives to apply
 - these tasks usually guide complex agent interactions....



Coordination: Definition 2

- Coordination as Constraining Interaction (Wegner)





Coordination: More Defs (1)

- “Coordination is the process of building programs by gluing together active pieces”
“A coordination model is the glue that binds together activities into an ensemble” (Carriero & Gelernter)
- “A coordination model provides a framework in which the interaction of active and independent entities ... can be expressed” (Ciancarini)



Coordination: More Defs (2)

- “The integration and harmonious adjustment of individual work efforts towards the accomplishment of a larger goal” (B. Singh)
- “Co-ordination is a way of adapting to the environment”
(von Martial)



Omicini/Ossowski's Coordination

- Coordination as *Representation* (CS)
 - modelling of the (agent) interaction space
 - coordination models as means to (formally) represent interactive systems
- Coordination as *Activity* (SE)
 - govern of the (agent) interaction space
 - coordination models and technologies as means to rule and manage interactive systems



Objective vs. Subjective

- Subjective Models / Mechanisms
 - coordination from within agents
 - individual viewpoint over interaction/coordination
- Objective Models / Mechanisms
 - coordination from outside agents
 - “external” viewpoint over interaction/coordination
- Separation of Concerns
 - impact over both (CS and SE) acceptations of the term
 - independent notion of social intelligence (AI)



Embodying Objective Coordination

- *Ad hoc* implementations
 - adapt agent architectures/ programmes
 - DCSP algorithms, . . .
- Coordination *middleware*
 - specialised abstractions
 - mediators, directory services, ontologies
 - general coordination abstractions
 - tuple centres, manifolds, blobs

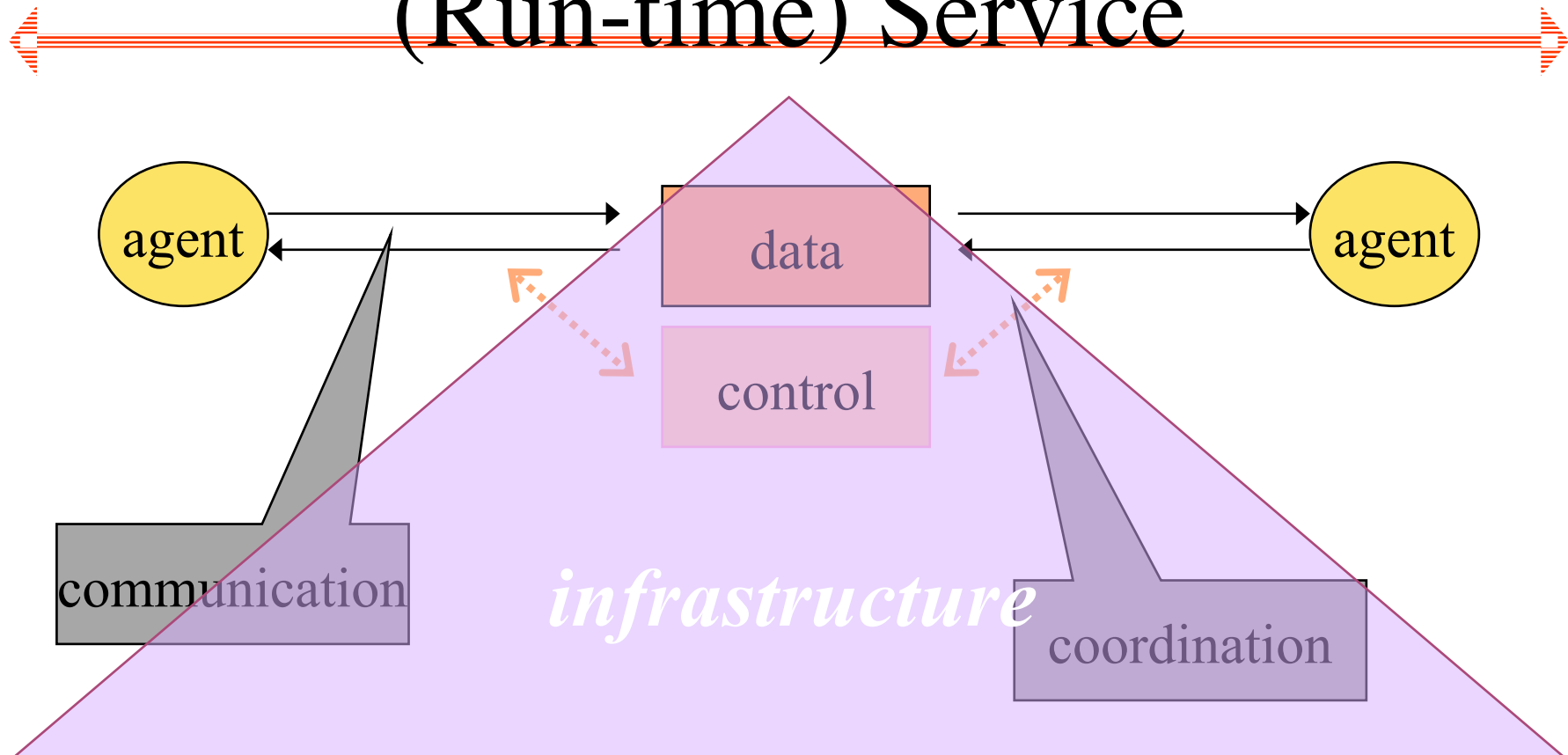


Coordination as a Service

- Coordination Abstractions as Run-times
 - from design down to deployment
- Encapsulating Coordination Laws
 - social laws / social norms
- Open Environments
 - agents free choose to use a service
 - and adopt its laws coming for free



Objective Coordination as a (Run-time) Service





Coordination as a Service:

An Example (a)

- Workflow Management in Virtual Enterprises
- Issues
 - technology / infrastructure heterogeneity
 - knowledge source heterogeneity
 - business process heterogeneity
 - new specific VE processes



Coordination as a Service:

An Example (b)

- You need
 - infrastructure
 - mediation
 - dynamic workflow management
 - workflow as a service
 - workflow rules as coordination rules
 - coordination media as workflow engines
 - encapsulating workflows into run-time services



Social Issues in the Construction of Agent Systems

Part IV



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Engineering the (Agent) Interaction Space

- Need for specific high-level abstractions and powerful mechanisms
 - to support the analysis, design and development of multiagent systems as far as interaction is concerned
 - Suggesting/supporting methodologies for the construction of open, distributed, heterogeneous, and mobile (agent) systems
 - Intrinsically providing systems with features of flexibility, security, support for heterogeneity, intelligence, ...



Roles vs. Organizations

- In a multiagent system, agents must be enabled to inter-operate to fulfil their role in the system
- Globally, the interactions between the different roles have to follow specific rules for the overall organization to work correctly and efficiently



Individual vs. Social Tasks

- Individual Tasks
 - Agents, as individuals, must be enabled to sense and affect their environment and the other agents living in that environment to survive and reach their own goals
- Social Tasks
 - The whole society, can't be left in anarchy, as it serves a more general – supra-agent – goals



Task-driven MAS Design

- Individual & Social Tasks
 - driving the design
- *Delegation of Responsibility*
 - agents (and societies) encapsulate control
- Impact on the Design
 - individual tasks $\Rightarrow$ design of single agents
 - social tasks $\Rightarrow$ design of
 - agent interaction protocols
 - agent interaction rules



Modelling Agent Societies

- Society = individuals + social rules
- Social laws rule behaviours and interactions
- Social law as coordination laws
- Agent society =
agents + coordination abstractions



Designing Agent Societies (a)

- Defining social task(s)
- Designing
 - social / individual roles
 - interaction protocols
 - social laws



Designing Agent Societies (b)

- Choosing the suitable coordination
 - mechanism
 - model
 - pattern
- Designing society upon/around coordination
 - laws
 - invariant
 - media



Developing Agent Societies

- Coordination technology
 - infrastructures, run-times
 - coordination as a service
- Coordination-specific IDE
 - monitoring / inspecting the interaction space
 - need for tools mapping abstractions into manageable metaphors



Society Design & Development:

An Example

- Designing WF Participants as Agents
- Designing WFs as Agent Societies
- Designing WF Engines as Coordination Media
 - embodying WF rules as coordination rules
- Example: Using Tuple Centres as WF Engines
 - prescriptive / objective coordination approach
 - generative communication
 - inspectability of interactions
 - “generative coordination”
 - explicit representation of WF rules
 - inspectability of laws
 - incremental / dynamic modification
 - subjective issues
 - coordination technology / IDE



Subjective/Objective Coordination in Design

- Designer's interest in Coordination

Micro-level design

- given an *open* environment with multiple agents
- built *one* additional agent with desired characteristics

subjective

open environment

- uncontrolled agents
- enforcement of coordination laws

Macro-level design

- build *systems* of multiple agents with desired characteristics

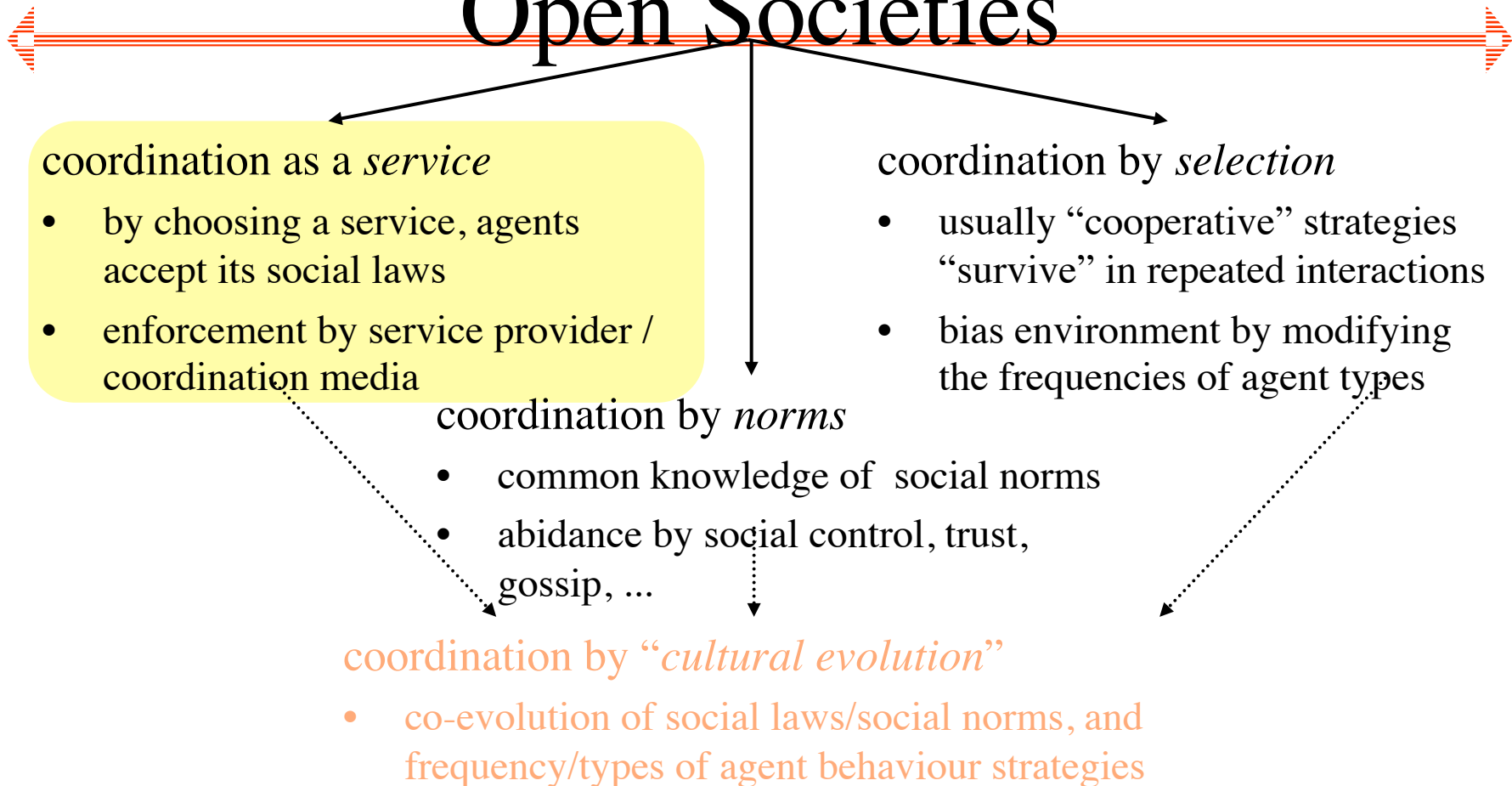
closed environment

- controlled agents
- problem-solving systems

objective



Coordination Mechanisms in Open Societies





The Role of Infrastructures

- Multiplicity of MAS and apps
 - Working together
 - Sharing needs and requirements
- Social Abstractions
 - As services provided by infrastructures
 - eg. knowledge mediators, coordination media, security-related services, etc.



Coordination Infrastructures

- Providing
 - Coordination as a service
 - Through coordination abstractions
 - Encapsulating coordination / social laws
- Abstractions
 - Formally defined
 - Supporting verification
 - From design to run-time
 - Supporting incremental refinement

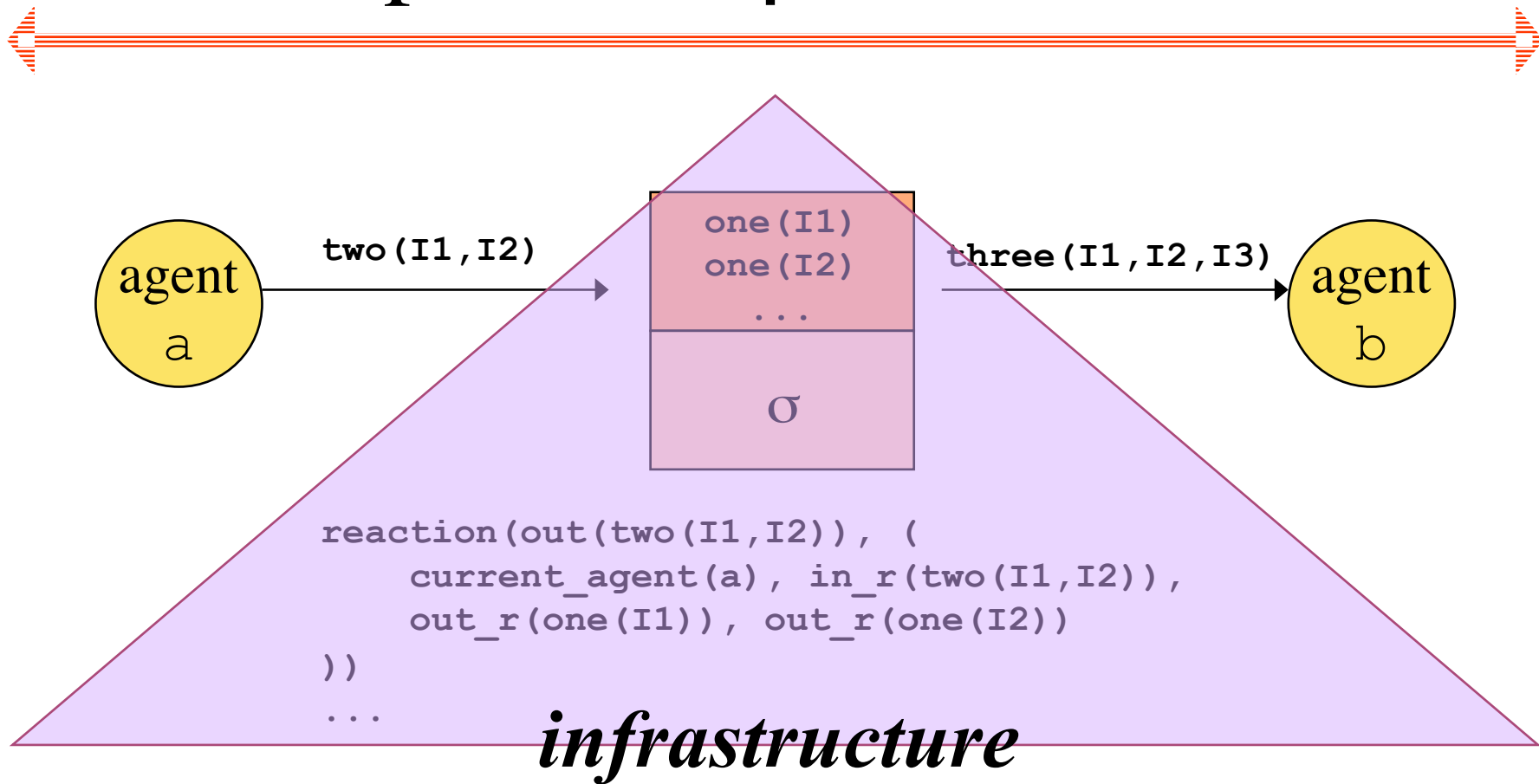


Coordination Laws

- Prescriptive
- Inspectable
 - By humans
 - Acting as gods
 - By agents
 - Enabling reflection
- Dynamically modifiable
 - Promoting self-adaptation



Example: ReSpecT/TuCSon





Agent Coordination Context

- Coordination Laws: Dynamically Bounded Interaction
 - provided by the infrastructure
- Reversing the OO Notion of Interface
 - meta-level description of the boundaries
 - protocols for negotiating / paying for boundaries?
- Example: *Control Room* Metaphor
 - lights and screens (for bounded inputs)
 - buttons and microphones (for bounded outputs)



Design of Social Laws

- Description of Social Laws
 - description language
 - enactment
- Global Effect of Social Laws
 - How to predict the influence of social laws to agent behaviour?
 - if social laws are too restrictive, agents won't choose the corresponding coordination service
 - if they are weak, it is not always clear in which direction they will bias the global system behaviour
 - mechanism design, libraries of social laws, . . .



Final Ads

- Come to Agent Conference!
 - AAMAS 2002, 15-19 July 2002
<http://lia.deis.unibo.it/confs/aamas2002>
- Submit to ACM SAC 2003!
 - <http://lia.deis.unibo.it/confs/sac03>
 - Special Track on Coordination Models, Languages and Applications
- Come to Cesena!
 - to visit the first ICT Engineering Faculty in Italy

