

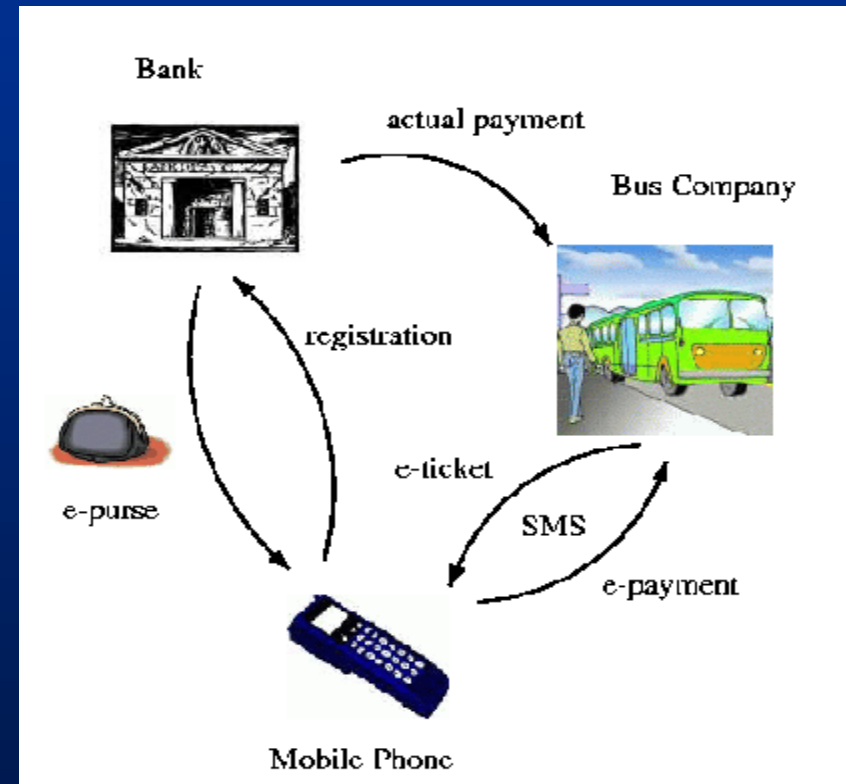
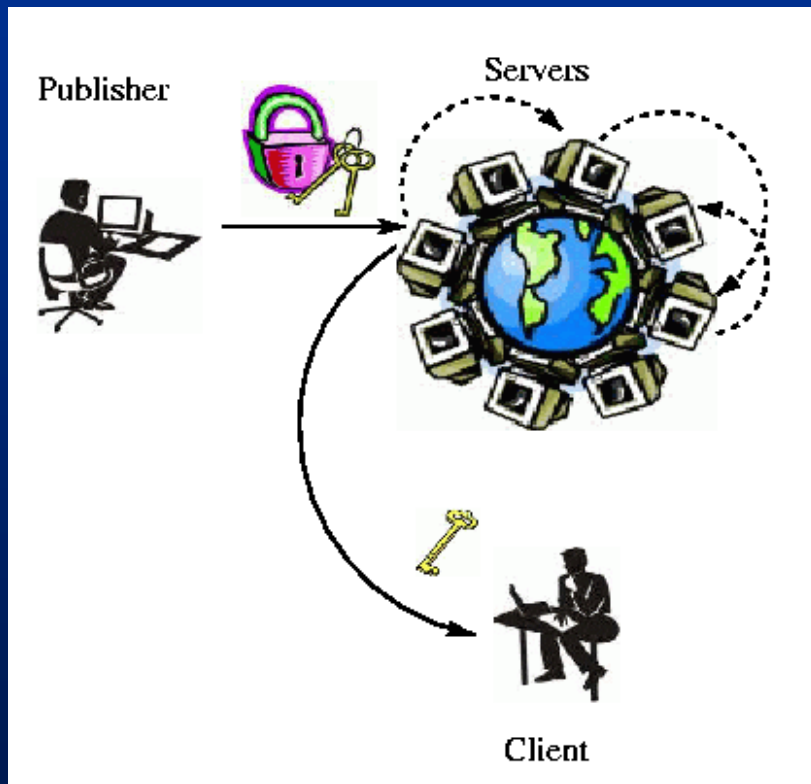
Engineering Emergent Behaviour: A Vision

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Outline

- Today's Applications
- Natural Life Mechanisms
- Electronic Counterpart
- How to Engineer SOAs?

Today's Applications (1)



Today's Applications (2)

- Internet / Distributed computing / WWW
- Wireless / Ad-hoc networks
 - Bluetooth / WiFi / PDA-based spontaneous networks
 - E-purses / Ad-hoc routing
- P2P systems
 - File backup systems
- Grid
- Agent-based systems

Today's Applications (3)

- Features
 - Decentralised
 - Pervasive
 - Based on autonomous entities (e.g., PDAs, Agents)
 - Adaptable
 - Social dimension (interactions, discovery, negotiation, transactions)

Self-Organising Systems (1)

- Self-Organisation

« System structure appears without explicit pressure from outside the system. »

- Biology

- Immune Systems
- Social Insects Paradigms
 - Stigmergy

- Human Systems

- Societies, Economies, ...

Self-Organising Systems (2)

- Features
 - Decentralised Control
 - Local contextual interactions
 - Emergent coherent result (emergent properties are not found in the components)
 - Complex tasks realised by simple components
 - Adaptation of global system to environmental changes
 - Self-maintenance (self-repair)

Self-Organising Applications (SOAs)

- Today's applications!
 - E.g. WWW
- Tomorrow's Applications: Biologically inspired
 - Self-organising sensor networks
 - self-monitoring, self-repairing aerospace vehicles
 - environmental monitoring problems
 - Autonomic Computing
 - Self-healing, self-repairing
 - Self-protection
 - Analogy: autonomic human nervous system

➤ Today's and Tomorrow's applications tend to be SOAs

Natural Mechanisms ...

- Insect Societies
 - Indirect Communication
 - Pheromonal information
- Human Societies
 - Communication, Negotiation, Economies, Markets
- Biology
 - Transparent Management of Vital Functions
 - Human Nervous System

... and their electronic counterpart

- Translation from natural systems
 - Digital pheromones
 - Collective intelligence, swarm intelligence
- But also ...
 - Agents coordination
 - Service descriptions
 - Ontologies

Traditional Engineering

- Engineering techniques and methodologies to
 - Design, deploy, maintain, verify applications
- Techniques
 - Interaction (patterns) fixed at design time
 - Fixed interfaces
 - Ontologies, Web services
- Methodologies
 - Local vs global goal of application
 - Global view, global behaviour is the sum of local behaviours
 - (Formal) Verification
 - Test, Model checking, Simulation

SOAs Engineering

- Needs ...
 - Global view
 - How to design the local behaviour so that global behaviour emerges?
 - Components have their own functionality
 - Global goal is NOT sum of local goals!!
 - Verification
 - Components: traditional verification
 - Global emergent behaviour
 - Simulation ... is simulation ☺
 - Other, more formal techniques for verifying the implementation?

What is already available?

- Coordination and Control using Stigmergy
 - Intrusion detection and response in network [Foukia03]
 - Manufacturing control [Valckenaers01]
- Interaction Models
 - Tags [Hales03]
 - Markings attached to agents and observed by other agents
 - Co-Fields [Mamei03]
 - Fields propagated in common space
 - Formally capture information
 - Unifying framework

What is already available?

- Middleware Approaches to Self-Organisation
 - Uncoupled interaction mechanisms
 - Autonomously propagating tuples in tuple spaces [Mamei03]
- Evolutionary Approaches
 - Selection of best strategy in electronic markets [Babanov03]
- Verification
 - Simulations

Challenges!

- Applications that work by themselves
- Software engineering methodologies
 - Define global goal
 - Design of components with local goal
 - Interactions
 - Verification

Summary

- Today's Applications tend to be SOAs
- Engineering
 - Simulation
 - Translation from natural life mechanisms
 - Need for additional mechanisms
 - Need for new engineering techniques

Conclusion

- Engineering Self-Organising Applications (ESOA) working group
 - Agentcities.Net project
 - Output Documents
 - <http://www.agentcities.org/Activities/WG/ESOA>
- ESOA'03 Workshop (tomorrow!)
- ESOA Tutorial (this afternoon)