Tuple Centres Spread over the Network (TuCSoN)

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TuCSoN Coordination Model [Omicini and Zambonelli, 1999]

Main Features

- Infrastructure providing services enabling the coordination of distributed/cuncurrent independent agents
- Supports agent coordination providing tuple centres – shared & reactive information spaces – distributed over the infrastructure nodes
- Agents insert, consume and read information in the form of tuple—ordered collections of heterogeneous information chunks.

Tuple Centres [Omicini and Denti, 2001]

Main Features

- Programmable tuple spaces

→ tuple spaces with a reactive behaviour which can be programmed dynamically

- Software components access tuple centres associatively by writing, reading, and consuming tuples via simple communication operations: out, rd, in, inp and rdp

Generative communication

- Agents communicate by creating and retrieving associatively tuples whose existence – once created – is independent with respect to agents' one.

→ This makes it possible to obtain uncoupling properties – temporal and spatial – leading to the openness requirement of software systems

Tuple Centres [Omicini and Denti, 2001]

Runtime First-class Abstractions [Ricci et al., 2005]

- Malleability. The coordination behaviour can be adapted and changed dynamically.
- Inspectability. The communication and the coordination state can be inspected at runtime.
- Controllability. The execution can be controlled by means of proper infrastructure tools.

Tuple Centres in TuCSoN

- Tuples are logic tuples: first order logic terms (like Prolog terms)
- Differently from tuple spaces, the behaviour of tuple centres in response to communication events can be tailored to the application needs by defining a set of specification tuples expressed in the ReSpecT language [Omicini, 2007].

TuCSoN Topology

- Tuple centres are collected in infrastructure nodes, distributed over the network, organised into articulated domains
- A domain characterised by a gateway node and a set of nodes called places
    - A place node is meant to host tuple centres for specific applications/systems
    - A gateway node is meant to host tuple centres used for domain administration, keeping information on the places ($ORG tuple centre)
    - A place can belong to different domains, and can be itself a gateway for a sub-domain

TuCSoN Organisations

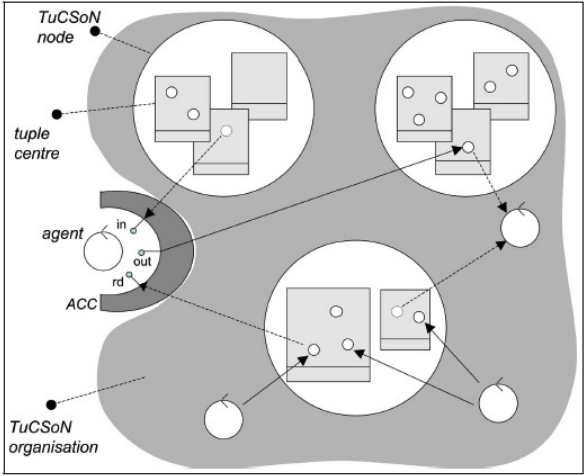
Organisations

- Tuple centres are structured and ruled in organisations
- Agents can be thought as a sort of society (permanent or temporal) with a specific objectives
- An organisation can be conceived as a static as well as dynamic set of societies
- Such societies are composed by agents playing some roles
- Role-based access control (RBAC) to integrate organisation and security

TuCSoN ACC

- Agent Coordination Context (ACC)
- A runtime and stateful interface released to an agent to execute operations on the tuple centres of a specific organisation
- A sort of interface provided to a agent by the infrastructure to make it interact within a certain organisation environment
- An organisation abstraction to model RBAC in MAS

TuCSoN Node


TuCSoN node
tuple centre
agent
in
out
rd
ACC
TuCSoN organisation

TuCSoN Technology

TuCSoN API

- Java and Prolog
- Heterogeneous hardware support

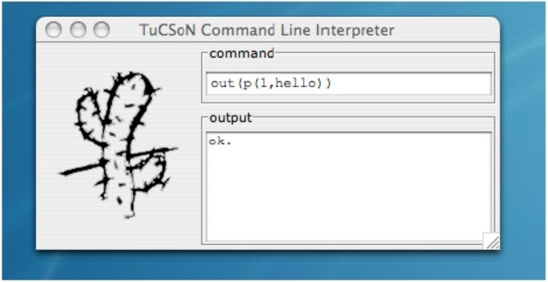
TuCSoN Service

- The host becomes a TuCSoN Node

TuCSoN Tools

CLI-Agent Tool

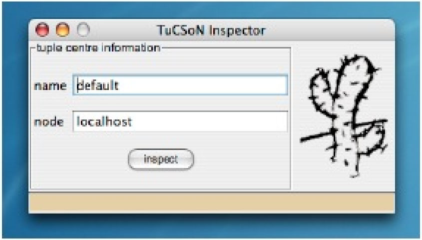
- Shell interface for human agents



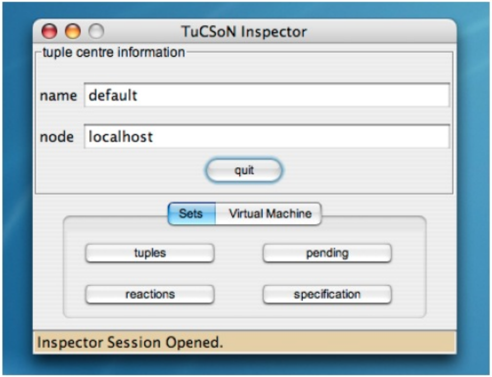
TuCSoN Tools

InspectorTool

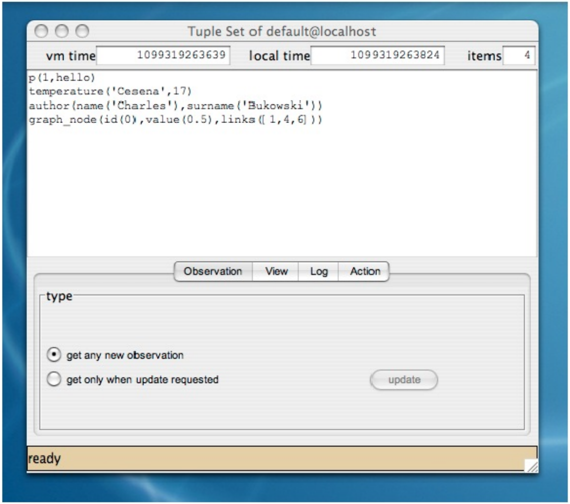
- Fundamental tool to monitor tuple centre communication and coordination state, and to debug tuple centre behaviour



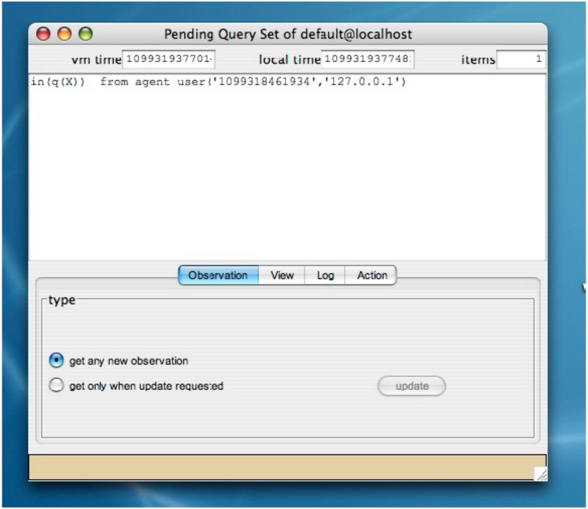
Inspector Tool



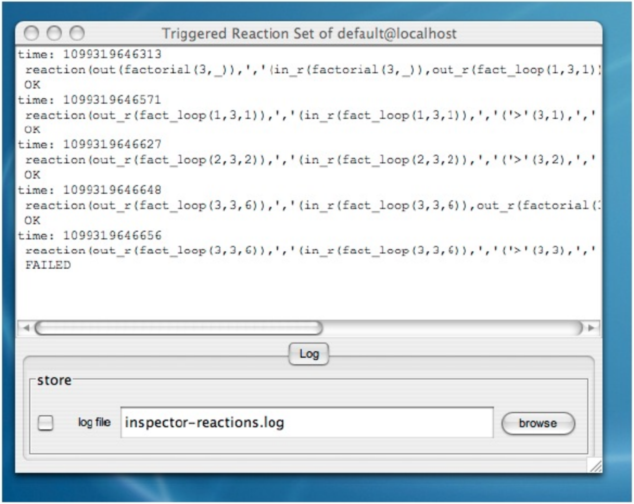
Inspector Tool



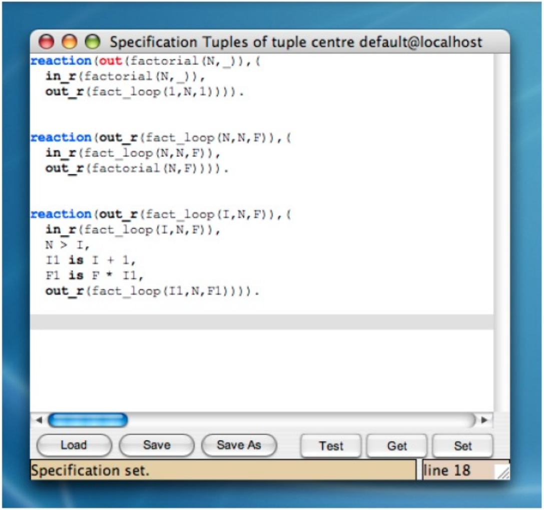
Inspector Tool



Inspector Tool



Inspector Tool



Example 1: Hello World

```java
package alice.tucson.examples.basic;

import alice.tucson.api.*;

public class HelloWorld
{
    public static void main(String[] args) throws Exception
    {
        TupleCentreId tid = null;

        if (args.length == 0)
            tid = new TupleCentreId("default");
        else
            tid = new TupleCentreId(args[0]);

        TucsonContext cnt = Tucson.enterDefaultContext();

        long now = System.currentTimeMillis();
        LogicTuple tuple = new LogicTuple("msg", new Value("Hello world!"),
                new Value("time", new Value(now)));

        cnt.out(tid, tuple);
        System.out.println("Tuple inserted: " + tuple);

        LogicTuple template = new LogicTuple("msg", new Var("Msg"), new Var("Time"));
        LogicTuple msg = cnt.in(tid, template);

        System.out.println("Tuple retrieved name: " + msg.getName());
        System.out.println("Msg argument: " + msg.getArg(0));
        System.out.println("Time argument: " + msg.getArg(1).getArg(0));
    }
}
```

Example 2: Java Agent

```java
import alice.logictuple.*;

import alice.tucson.api.*;

public class MyAgent extends Agent
{
    protected MyAgent(String name) throws TucsonException
    {
        super(name);
    }

    protected void body()
    {
        try
        {
            TupleCentreId tid = new TupleCentreId("test_tc");
            out(tid, new LogicTuple("p", new Value("hello world")));

            LogicTuple t = new LogicTuple("p", new Var("X"));

            System.out.println(t);
        }
        catch (Exception e)
        {
            e.printStackTrace();
        }
    }
}
```

Example 3: Java Agent Test

```
public class Test
{
    public static void main(String[] args) throws Exception
    {
        new MyAgent("alice").spawn();
    }
}
```

Example 4: Prolog Agent

```
:- load_library('alice.tucson.api.Tucson2PLibrary').
:- solve(go).

go:-
  enter_context([agent_id(hank)]),
  test_tc ? out(p('hello world')),
  test_tc ? in(p(X)),
  exit_context, write(X), nl.
```

Outline

Thermostat Agent in Java

Requirements

- Check the environment temperature T.
- Until T is not: > 18 and < 22:
  - Decrease T of one unit if the temperature is 22
  - Increase T of one unit if the temperature is 18

Constraint

- thermostat is a tuple centre between the environment and the ThermostatAgent
- ThermostatAgent interacts with the tuple centre to communicate with the thermostat in order to sense and change the temperature
- The real thermostat is simulated by an agent

Outline

Thermostat Agent in Prolog

New Constraint

- ThermostatAgent becomes a Prolog agent

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