

Agent-Based Process Modelling for Virtual Enterprises

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(Management & Information Systems)**

Presentation Outline

- Introduction to Virtual Enterprises & Multi-Agent Systems
- Research Aim
- Research Objectives
- Methodology
- Multi-Agent Systems for VE Modelling:
 Overview of the ZEUS Toolkit
- Key Findings
- Conclusions
- Recommendations
- Future Research
- Summary

Introduction to Virtual Enterprises

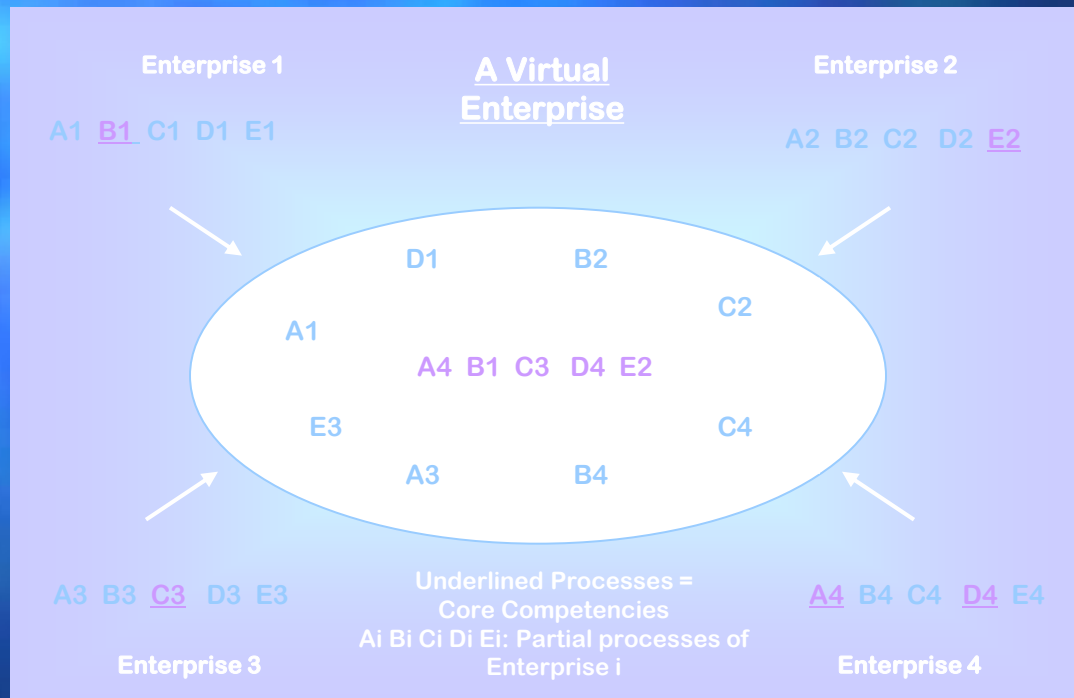
- **Definition of Virtual Enterprises:**

- **Davidow & Malone (1992)**

- **Arnold et al (1995):**

‘...a Virtual Enterprise is a cooperation of legally independent enterprises, institutions or individuals, which provide a service on the basis of a common understanding of business...the cooperation is maintained by using feasible information and communication technologies.’

Introduction to Virtual Enterprises



Source: Fischer et al (1996)

Introduction to Virtual Enterprises

- **Examples of Virtual Enterprises:**
 - F International: home-working
 - Dell Computer Corporation: mass-customisation
 - Amazon.com: competitive prices
 - British Airways (Waterside): virtual work
 - Levy Gee: virtual business consultancy

Introduction to Multi-Agent Systems

- **DAI emerged 20 years ago:**
 - **Weiss (1999):**

‘..the study, construction and application of Multi-Agent Systems..in which several interacting intelligent agents pursue some set of goals..’
- **What is an Agent?:**
 - **Ferber (1999):**

‘..a physical or virtual entity that can act, perceive its environment and communicate with others...is autonomous and has skills to achieve its goals & tendencies.’

Introduction to Multi-Agent Systems

Agent Properties:

- Reactive
- Proactive
- Social Ability

Agent Types:

- Competitive
- Cooperative

Agent Standards:

- FIPA
- OMG MASIF

Agent Toolkits:

- 'sets of components'
- 'sets of tools'

Examples of Multi-Agent System Applications:

- Analysis of business processes in enterprises
- Optimisation of industrial manufacturing processes
- Virtual Reality based computer games

Research Aim

‘Investigate the possibility of improving *communication* between enterprises, to enhance their *competitive position*. This will be done through exploring methods and software based on a Multi-Agent framework for the modelling of Virtual Enterprises.’

Research Objectives

- To conduct a literature review on Virtual Enterprises and Multi-Agent Systems.
- To assess the compatibility of Multi-Agent System applications for Virtual Enterprise modelling.
- Technical proficiency with the ZEUS toolkit.
- To develop a Virtual Enterprise Modelling System using a MAS methodology integrated within the ZEUS toolkit.
- To analyse and evaluate the feasibility of the ZEUS toolkit for Virtual Enterprise modelling
- To evaluate the suitability of Multi-Agent Systems for Virtual Enterprise modelling

Methodology

- Literature Review
- Industrial survey on Virtual Enterprises
- Technical Proficiency in using ZEUS
- Analysis & evaluation of ZEUS

MAS for VE Modelling

Benefits:

- VEs are composed of distributed, autonomous and heterogeneous components
- Distributed problem solving can be tackled
- Conflict management in VEs can be modelled using MASs

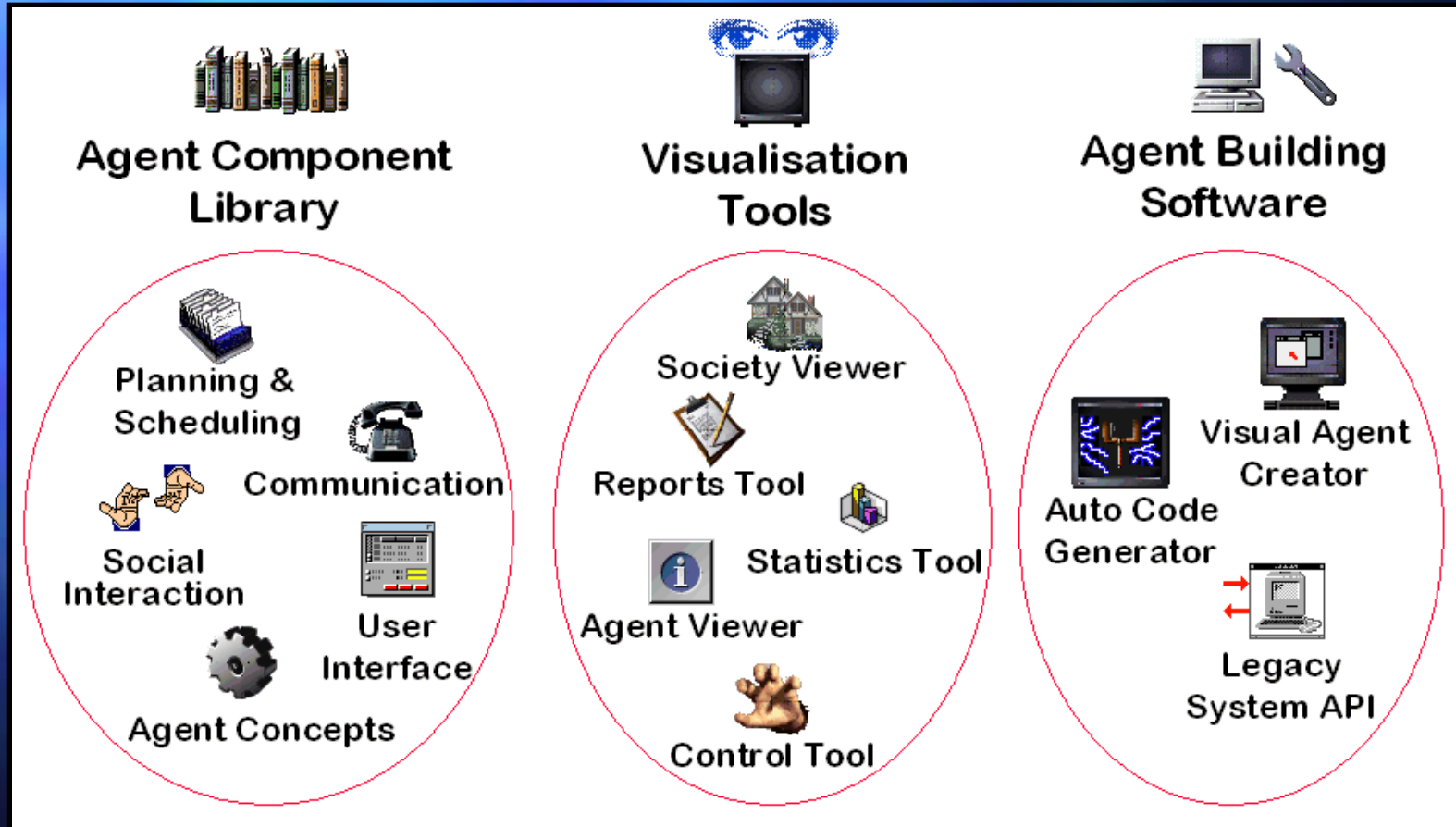
Drawbacks:

- Lack of infrastructure and definitive standards
- Security & virus mechanisms

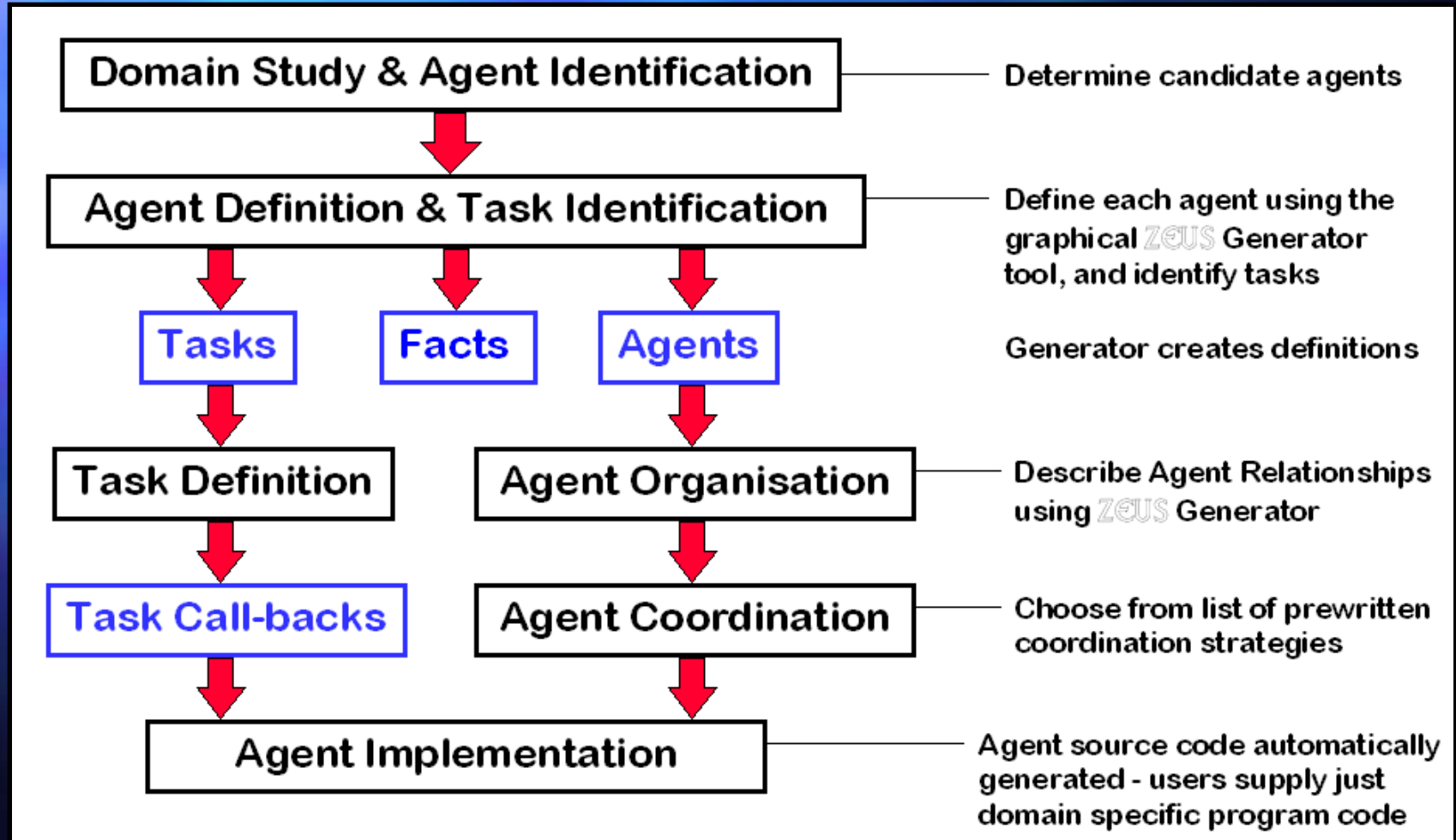
Research Gap:

- Use of the ZEUS toolkit in modelling Virtual Enterprises

The Components of the ZEUS Tool-Kit

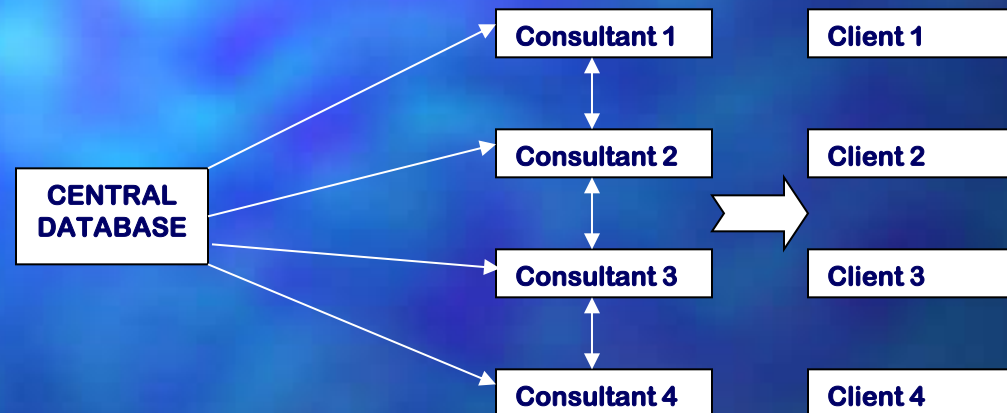


The Zeus Agent Design Methodology



CMBC Case Study

Participants & Interactions of Cranfield Manufacturing Business Consultancy

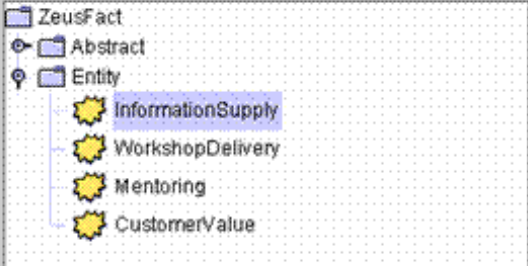


Ontology Editor

Ontology Editor: /rh/users/4/sims/

File

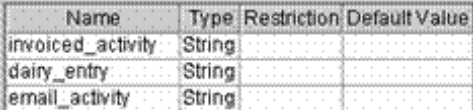
The Fact Hierarchy



```

graph TD
    ZeusFact --> Abstract
    ZeusFact --> Entity
    Entity --> InformationSupply
    Entity --> WorkshopDelivery
    Entity --> Mentoring
    Entity --> CustomerValue
  
```

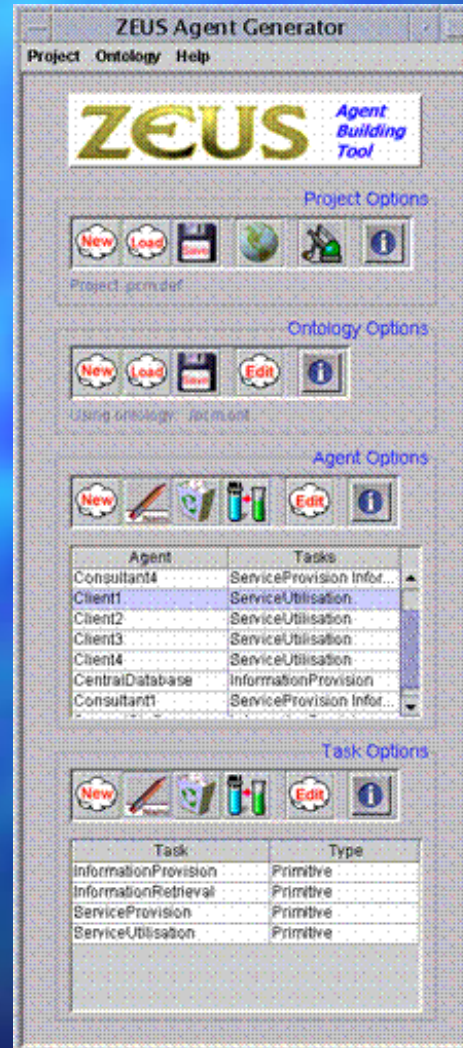
The Attributes specific to 'InformationSupply'



| Name | Type | Restriction | Default Value |
|-------------------|--------|-------------|---------------|
| invoiced_activity | String | | |
| dairy_entry | String | | |
| email_activity | String | | |

Known Facts | Restriction Definitions | Database Import

ZEUS Agent Generator



Task Definition

Agent Editor: Client1

Agent Definition Panel Client1

Planning Parameters

Maximum Number of Simultaneous Tasks: 1

Planner Length: 20

Task Identification

| Task | Type |
|--------------------|-----------|
| ServiceUtilisation | Primitive |

Initial Agent Resources

| Fact Type | Instance |
|-----------|----------|
| location | |
| unit_cost | |
| price | |
| number | |
| client_id | |

| Attribute | Value |
|--------------------|-------|
| unit_cost | |
| service_quality | |
| number | |
| satisfaction_level | |

Agent Definition Agent Organisation Agent Coordination

Primitive Task Editor: ServiceUtilisation

Task Preconditions and Effects ServiceUtilisation

Task

Task Preconditions

| Fact Type | Instance | Modifiers |
|------------------|----------|-----------|
| WorkshopDelivery | Two | |
| Mentoring | Five | |

Task Effects

| Fact Type | Instance | Modifiers |
|---------------|----------------|-----------|
| CustomerValue | ?CustomerValue | |

Task Cost and Time

Cost: (?CustomerValue number * 125)

Time: (1 * ?CustomerValue number)

Preconditions and Effects Constraints

Agent Organisation & Coordination

Agent Editor: Client1

Agent Organisation Panel Client1

Acquaintances

NEW Edit Delete Search Add Remove Cancel HELP

| Agent | Relation |
|-------------|-------------|
| Consultant1 | subordinate |

Acquaintance Abilities

NEW Delete Copy Paste HELP

| Ability Type | Cost | Time |
|------------------|------|------|
| WorkshopDelivery | 0.0 | 0 |
| Mentoring | 0.0 | 0 |

| Attribute | Value |
|-------------|-------|
| location | |
| unit_cost | |
| number | |
| price | |
| client_site | |

Agent Definition Agent Organisation Agent Coordination

Agent Editor: Client1

Agent Coordination Panel Client1

Coordination Protocols

Clear All HELP

| Type | Protocol | State |
|------------|------------------------------|-------------------------------------|
| Initiator | Fipa-Contract-Net-Manager | <input checked="" type="checkbox"/> |
| Respondent | Fipa-Contract-Net-Contractor | <input type="checkbox"/> |

Coordination Strategies

NEW All Delete Copy Paste HELP

| Mode | Fact Type | Agents | Relations | Strategy | Parameters |
|-------------------------------------|-----------|--------|-------------|----------------|------------------------|
| <input checked="" type="checkbox"/> | ZeusFact | null | subordinate | GrowthFunction | step.default=2 no.q... |

| Attribute | Value |
|-----------|-------|
| | |

Agent Definition Agent Organisation Agent Coordination

Code Generation

Code Generator

GENERATE **Clear** **CANCEL** ⓘ

Choose Target Directory: /rh/users/4/sims/wq063176/sun/examples/pcf.J...

Create Scripts for... Windows Unix

[Generation Plan](#)

Utility Agents Tasks Delete HELP

| Name | Type | Command Line |
|--------------------|-------------|---|
| Nameserver0 | Nameserver | java zeus.agents.ANServer Nameserver0 -L... |
| Facilitator0 | Facilitator | java zeus.agents.Facilitator Facilitator0 -o J... |
| Visualiser0 | Visualiser | java zeus.visualiser.Visualiser Visualiser0 -... |
| Client1 | Agent | java Client1 -o /examples/pcf/pcm.ont -s dn... |
| Client2 | Agent | java Client2 -o /examples/pcf/pcm.ont -s dn... |
| Client3 | Agent | java Client3 -o /examples/pcf/pcm.ont -s dn... |
| Client4 | Agent | java Client4 -o /examples/pcf/pcm.ont -s dn... |
| ServiceUtilisation | Task | |

[Generation Messages](#)

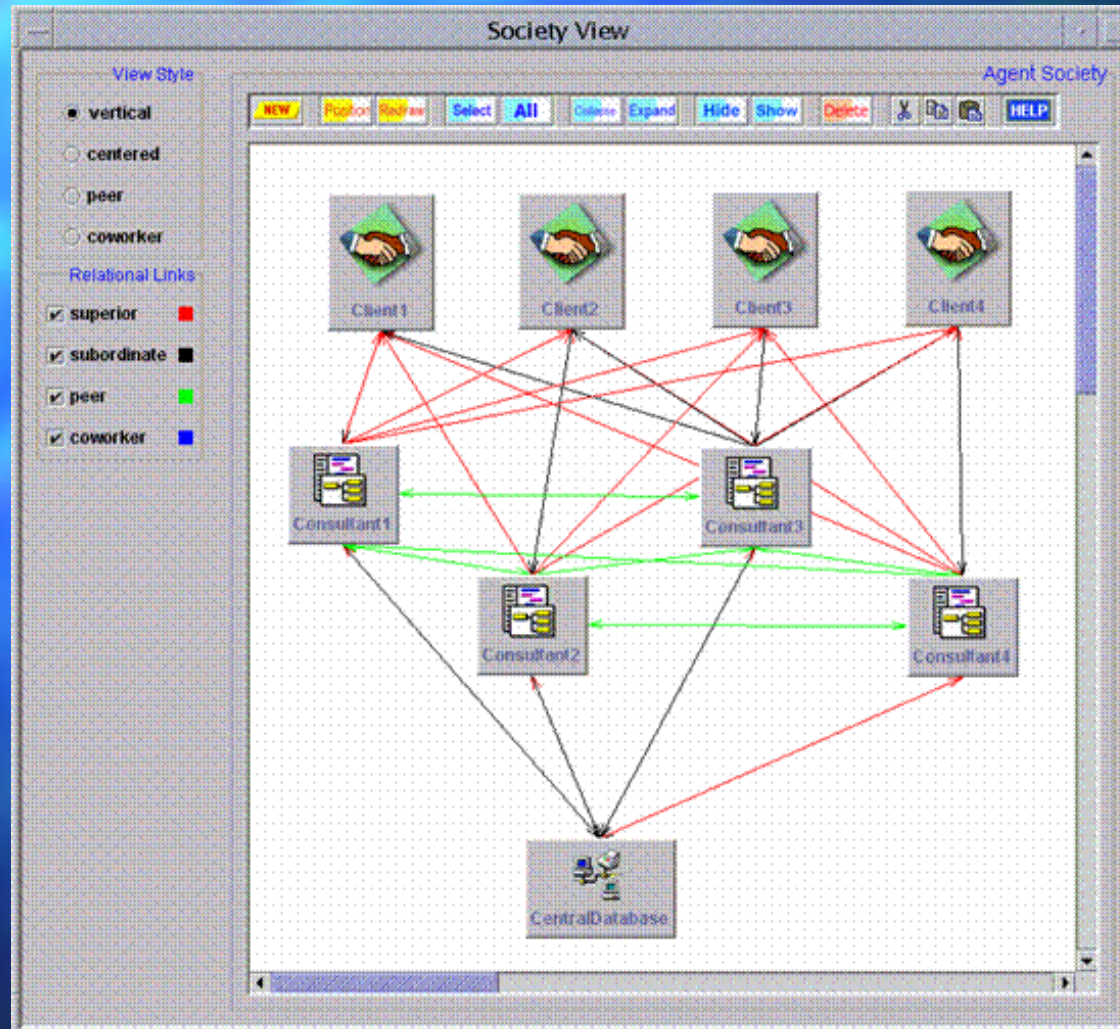
```

Attempting to write script: run1
Script: run1 written successfully
Attempting to write script: run3
Script: run3 written successfully
Attempting to write script: run2
Script: run2 written successfully
Setting script permissions.

*** Agent code generation started ***
    
```

Generation Plan Utility Agents Task Agents Tasks

Society View



Key Findings – MASs for VEs

- VEs are composed of distributed, autonomous and heterogeneous components, which can easily be decomposed and mapped into MAS applications
- The similarity in characteristics of VEs and MASs allows them to be used in combination
- If fundamental standards and ontologies cannot be established, this will lead to diverse applications for diverse purposes lacking congruency

Key Findings - ZEUS

- Installing ZEUS was a time-consuming process
- The domain analysis stage of the application development process required a wider variety of role models
- In the agent realisation process, the ZEUS interface was very easy to use
- The agent creation, definition and organisation processes were simple.
- The agent coordination process resulted in using the PC Manufacture case-study as a guide
- Technical difficulties when the application was implemented using UNIX

Conclusions

- VEs are currently significant organisational paradigms which will continue to gain significance in the future in a versatile range of industries
- Cultural and technological infrastructures must support VEs in order for them to be successful

Conclusions

- The ZEUS toolkit has the potential to be an effective application methodology for VE modelling, however, the discrepancies within it must be addressed
- If ZEUS software support could be improved, the CMBC case-study would not merely be used for illustrative purposes, but recommendations could have been made to the CMBC on how to improve their business processes: this is where the real value of ZEUS could have been tested

Recommendations

- Installation process could be made easier, with exact detailed instructions
- Online 'live' demonstrations of case studies would also be useful and more effective as a preview of the ZEUS suite of tools

Recommendations

- Improved software support through the following:
 - Online instant messaging boxes to provide immediate assistance
 - BTEExact Technologies could create a discussion database on their web-site to discuss ZEUS problems
 - E-mail response times could be improved

Future Research

- Investigations into using different open-source toolkits for VE modelling purposes
- Research into combining different systems methodologies for VE modelling, for instance, UML, system dynamics and ZEUS, to create a multi-methodology
- Comparisons into the OO and agent-based paradigms and how they can be used in complementary ways

Summary

- Introduction to VES & MASs
- Research Aim, Objectives & Methodology
- Feasibility of MAS for VE modelling:
Overview of ZEUS Toolkit
- Key findings of VEs & MASs
- Conclusions
- Recommendations
- Future Research

QUESTIONS

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