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)

  ‘...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

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

Agent Component Library:
- Planning & Scheduling
- Communication
- Social Interaction
- User Interface
- Agent Concepts

Visualisation Tools:
- Society Viewer
- Reports Tool
- Statistics Tool
- Agent Viewer
- Control Tool

Agent Building Software:
- Visual Agent Creator
- Auto Code Generator
- Legacy System API
The Zeus Agent Design Methodology

Domain Study & Agent Identification
- Determine candidate agents

Agent Definition & Task Identification
- Define each agent using the graphical ZEUS Generator tool, and identify tasks
  - Generator creates definitions

Tasks
- Describe Agent Relationships using ZEUS Generator

Facts
- Choose from list of prewritten coordination strategies

Agents

Task Definition

Task Call-backs

Agent Organisation

Agent Coordination

Agent Implementation
- Agent source code automatically generated - users supply just domain specific program code
CMBC Case Study

Participants & Interactions of Cranfield Manufacturing Business Consultancy

CENTRAL DATABASE

Consultant 1
Client 1

Consultant 2
Client 2

Consultant 3
Client 3

Consultant 4
Client 4
ZEUS Agent Generator

ZEUS Agent Generator

- Project Options
- Ontology Options
- Agent Options
- Task Options

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Task Definition
Agent Organisation & Coordination

[Image of a software interface for Agent Organisation and Coordination]
Code Generation
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
  - BTExact 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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