

# Agent-Mining Interaction and Integration

AMII: [www.agentmining.org](http://www.agentmining.org)

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University of Technology Sydney, Australia

# Introduction to Data Mining

## Outline

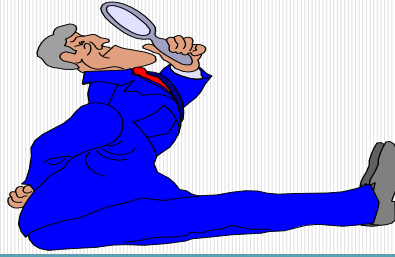
- Introduction to Data Mining
- Introduction to Intelligent Agent
- Bilateral Enhancement through AMII
- Overview of AMII Research and Development
- AMII Research Issues
- AMII Approaches and Techniques
- AMII Applications and Case Studies
- AMII References and Resources

## Contents

- What is data mining
- What are data mining topics
- What are data mining approaches
- Application areas
- What can data mining bring to us
- Challenges and issues

# Data Mining Is

- A hot buzzword for a class of techniques that find patterns in data
- A **user-centric, interactive process** which leverages analysis technologies and computing power
- A group of techniques that find relationships that have not previously been discovered
- Not reliant on an existing database
- A relatively easy task that requires knowledge of the business problem/subject matter expertise



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# Phases and Tasks

Business Understanding	Data Understanding	Data Preparation	Modeling	Evaluation	Deployment
<p><b>Determine Business Objectives</b> Background Business Success Criteria</p> <p><b>Situation Assessment</b> Inventory of Resources Requirements, and Assumptions, and Risks and Contingencies Terminology Costs and Benefits</p> <p><b>Determine Data Mining Goal</b> Data Mining Goals Data Mining Success Criteria</p> <p><b>Produce Project Plan</b> Project Management of the Project Management of Tools and Techniques</p>	<p><b>Collect Initial Data</b> Initial Data Collection Report</p> <p><b>Describe Data</b> Data Description Report</p> <p><b>Explore Data</b> Data Exploration Report</p> <p><b>Verify Data Quality</b> Data Quality Report</p>	<p><b>Data Set</b> Data Set Description</p> <p><b>Select Data</b> Rationale for Inclusion/Exclusion</p> <p><b>Clean Data</b> Data Cleaning Report</p> <p><b>Construct Data</b> Data Construction Report Generated Records</p> <p><b>Integrate Data</b> Merged Data</p> <p><b>Format Data</b> Reformatted Data</p>	<p><b>Select Modeling Technique</b> Modeling Assumptions</p> <p><b>Generate Test Design</b> Test Design</p> <p><b>Build Model</b> Parameter Settings Model Description</p> <p><b>Assess Model</b> Model Assessment Revised Parameter Settings</p>	<p><b>Evaluate Results</b> Assessment of Data Mining Results w.r.t. Criteria Approved Models</p> <p><b>Review Process</b> Review of Process</p> <p><b>Determine Next Steps</b> Possible Actions Decision</p> <p><b>Review Project Experience</b> Documentation</p>	<p><b>Plan Deployment</b> Deployment Plan</p> <p><b>Plan Monitoring and Maintenance</b> Maintenance Plan</p> <p><b>Produce Final Report</b> Final Presentation</p>

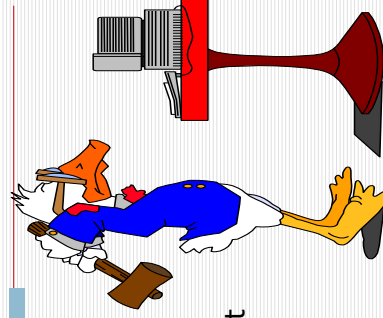
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# Data mining is not

- Brute-force crunching of bulk data
- "Blind" application of algorithms
- Going to find relationships where none exist
- Presenting data in different ways
- A database intensive task
- A difficult to understand technology requiring an advanced degree in computer science



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# Classification of Data Mining Methods: A Multi-Dimensional View

- Data to be mined**
  - Relational, data warehouse, transactional, stream, object-relational, active, spatial, spatiotemporal, time-series, text, multi-media, heterogeneous, legacy, WWW
- Knowledge to be mined**
  - Characterization, discrimination, association, classification, clustering, trend/deviation, outlier analysis, etc.
  - Multiple/integrated functions and mining at multiple levels
- Techniques utilized**
  - Database-oriented, OLAP, machine learning, statistics, visualization, etc.
- Application-oriented**
  - Biological, engineering, retail market, telecommunication, banking, fraud detection, intrusion detection, stock market, social network analysis, etc.

-- Prof. Jiawei Han

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## What are data mining topics

- Classification, clustering, association, correlation, statistics
- Data mining in data streams and sensor databases
- Sequential pattern and structured pattern mining
- Data mining across multiple, heterogeneous data sources
- Multi-dimensional data analysis
- Spatial-temporal data mining
- Web mining for construction of global information systems
- Biological data mining
- Data mining for protection of security and privacy
- Social network, hidden linkage and their evolution
- Data mining for software/system engineering (debug)
- Feedback to DBMS: graph-indexing, query optimization

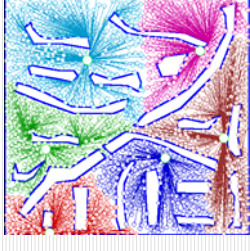
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## Application areas

- Fraud detection
- Customer relationship management
- Churn analysis
- Risk analysis
- Financial data mining
- Intelligent transport mining
- Web mining
- Text mining
- National/homeland security analysis
- Bioinformatics
- Blog mining
- Taxation mining
- Market surveillance pattern analysis
- Social security mining, etc.



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## Traditional vs. Advanced Data Mining

- Traditional data mining: Typical data mining methods
  - Data preprocessing: Data cleaning, data integration and data reduction
  - Multidimensional and OLAP analysis methods
  - Association and frequent pattern analysis
  - Classification and model construction
  - Cluster analysis and outlier detection
  - Typical data mining applications
- Advanced data mining
  - Scalable data mining methods
  - Stream data mining
  - Mining spatiotemporal data and multimedia data
  - Biological data mining
  - Text and Web mining
  - Privacy-preserving data mining
  - Social network analysis, Link mining
  - Multiple data source mining
  - Exceptional behavior analysis

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## What can data mining bring to us

- Identifying exceptional behavior to indicate proactive Intervention
- Forecasting what may happen in the future
- Classifying people or things into groups by recognizing patterns
- Clustering people or things into groups based on their attributes
- Associating what events are likely to occur together
- Sequencing what events are likely to lead to later events

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## What can data mining bring to us

- Fraud/Non-Compliance Anomaly detection
  - Isolate the factors that lead to fraud, waste and abuse
  - Target auditing and investigative efforts more effectively
- Credit/Risk Scoring
- Intrusion detection
- Parts failure prediction
- Recruiting/Attracting customers
- Maximizing profitability (cross selling, identifying profitable customers)
- Service Delivery and Customer Retention
  - Build profiles of customers likely to use which services

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## What can data mining bring to us

- Strengths
  - Exploring huge, complex, mixed data
  - Deep data analysis
  - Hidden knowledge discovery
  - Data tells us the story
- Weaknesses
  - Data itself is not sufficient for intrinsic patterns
  - Little focus on system infrastructure
  - Weak in dealing with social/organization complexity such as distribution, dynamics

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## Challenges and issues

- Data sources
  - Dynamic data
    - Data is evolving
  - Multiple data sources
    - Multiple
    - Distributed
  - Peer-peer data
  - Rare and dispersed links
  - Distributed online data
  - Mixed data

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## Human roles in setting up a project

- Business understanding staff
- Problem definition staff
- Data extractors
- Data matchers
- Data miners
- Data modelers
- Pattern assessors
- Business interpreters
- Project managers
- Approvers

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- Infrastructure
  - Remote data access
  - Dynamic mining support
  - Distributed mining support
  - Parallel mining support
  - Domain knowledge support
  - Business-human-system interaction
  - Evaluation support
  - Decision-making support

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## Introduction to Intelligent Agent

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- Decision making
  - Knowledge actionability
    - Large number of rules/patterns identified
    - Few are of business interest
  - Interestingness
    - Technical, business
    - Subjective, objective
    - Benefit-cost analysis
    - Risk assessment
  - From learned rules to decision actions
  - Delivery constraints

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## Contents

- What is intelligent agent
- What are intelligent agent topics
- What are intelligent agent approaches
- Application areas
- What can intelligent agent bring to us
- Challenges and issues

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## What is intelligent agent

- A controversial concept
  - Artificial intelligence: proactivity, intelligence, ...
  - Software engineering: computing component with internal threads of execution for complex interaction
- Agent diversity
  - Proactive agent: goals,
  - Situated agent: perceptions, actions
  - Reactive agent: events
  - Cognitive agent: BDI
  - Mobile agent: mobility
  - Social agent: societies
  - Hybrid agent

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## What are intelligent agent topics

- Agent properties and attributes
  - Autonomous, selfish, deliberative, rational...
- Agent communication and interaction
  - Cooperation, collaboration, negotiation, human-agent interaction, ...
- Agent learning
  - Learning, reasoning, adaptation, evolution...
- Agent organization and society
  - Organizational rules, structure, norms, environment, dynamics, privacy, trust, reputation, self-organization, emergence, swarm intelligence, legality, ethics...
- Agent structure and architecture
  - BDI, reactivity, bounded rationality,
- Agent-oriented software engineering
  - Goal, role, service, organization, communication, ...
- Agent-based system development
  - Protocol, modeling, language, platform, tools, ...

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## Attributes and properties

- Individual level
  - Autonomy, proactivity, reactivity, situatedness, ...
  - Action, adaptation, belief, desire, evolution, goal, intention, learning, perception, reasoning, ...
- Group level
  - Cooperative, coordinative, communicative, collaborative, competitive,
  - Commitment, communication, conflict handling, emergence, goal, interactivity, matchmaking, negotiation, planning, reputation, role, rule, organization, society, trust...

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## What are intelligent agent approaches

- Logic-based methods
  - First order logic, ...
- Soft computing based methods
  - NN, GA, SOM, ...
- Software engineering based methods
  - ER, goal-based, organization-oriented, ...
- Simulation based methods
  - Auction, trading agent, mechanism design, ...
- Organizational and societal methods
  - Economics, law, ethics, organization, complexity sciences...
- IT based methods
  - XML, web service, Java services...
- Cognitive science
  - BDI, ...

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## Approaches available

- Specifications
  - FIPA, OMG, ...
- MAS methods and techniques
  - AUML, GAIA, OSOAD, Tropos, Message, MaSE, AML, OPM/MAS, MDA/MDE, INGENIAS, META-DIMA, MINERVA
- Programming language and tools
  - JACK, JADE, AgentSpeak, Jason, Madkit, 3APL, AgentBuilder, AgentFactory, Prometheus,...
  - Prolog, Java, SmallTalk, Erlang,...

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## What can intelligent agent bring to us

- Agents as a new computing paradigm for complex problems and systems
  - Complex problem-solving paradigm
  - Complex intelligent system building paradigm
  - Complex software construction paradigm
    - autonomous, cooperative, distributed, intelligent, interactive systems and approaches

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## Application areas

- Software engineering
  - System abstraction, analysis, design, implementation
- Simulation
  - Finance, e-commerce, transport, game theory, marketing, social science, emergence, societal issues,...
- AI and intelligent systems
  - New intelligence, swarm/collective/emergent intelligence
  - Artificial intelligent systems
  - Reasoning and planning
  - Intelligent system building, ...

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- Strengths
  - Integrate multiple data sources and applications in distributed and mobile environment
  - Understand, abstract, analyze complex problems, and design complex systems
  - Build flexible and autonomous infrastructure
  - Involve human intelligence through user-agent interaction
  - Handle social complexity such as distribution, dynamics, interaction, evolution, self-organization
  - Represent and simulate intelligence and recognition, study the emergence of collective intelligence, say swarm intelligence

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# Challenges and issues

- Data exploration and integration
  - Huge volumes of data
  - Complex data structure
- In-depth analysis and learning
  - Learning from data, historical analysis, relationship analysis, pattern analysis, forecasting, trend analysis, exceptional behavior analysis, dimensionality reduction...
  - Recommendation, optimization
- Knowledge engineering
  - Domain knowledge, knowledge representation, transformation, mapping, semantic relationship

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# Bilateral Enhancement through AMII

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# Contents

- Objectives complementation between data mining and intelligent agent
- Strengths complementary
- Complementary strategies in handling respective challenges through agent-mining interaction

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- Quantitative modeling techniques
  - Quantifying agent's attributes/properties
  - Quantifying agent's objectives and/or expectations
- Evaluation mechanisms
  - Verifiable, repeatable models, algorithms, strategies, etc.
  - Training/test process
  - Measuring performance: Technical interestingness, business preferences
  - Performance of agent system, design strategies and architectures

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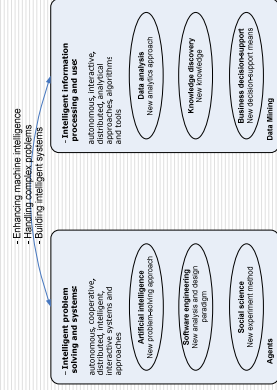
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# Objectives complementation

- Intelligent problem-solving
- Agent: intelligent problem-solving systems
- Data mining: intelligent information processing and use

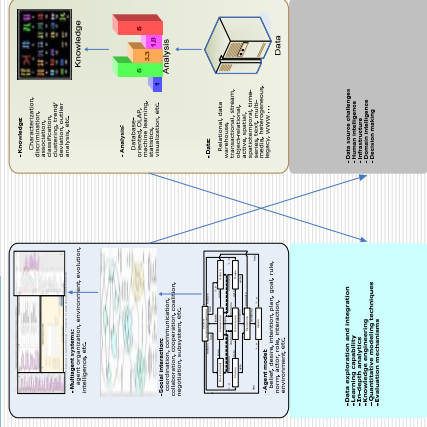


# Complementary strategies in handling respective challenges

Items	AAMAS	KDD/DM
Data	<ul style="list-style-type: none"> <li>• Data passing</li> <li>• Data integration</li> <li>• Remote data access</li> </ul>	<ul style="list-style-type: none"> <li>• Complex data understanding</li> <li>• Data exploration</li> <li>• Data preparation</li> </ul>
Domain	<ul style="list-style-type: none"> <li>• Environment</li> <li>• Human-agent interaction</li> <li>• Organizational factors</li> <li>• Social behavior and computing</li> <li>• Knowledge representation</li> </ul>	<ul style="list-style-type: none"> <li>• Domain knowledge</li> <li>• Human interaction</li> <li>• Human knowledge</li> <li>• User preferences</li> <li>• Business logics</li> <li>• Constraints</li> <li>• Privacy, trust, security...</li> <li>• Workability, dependability</li> </ul>
Knowledge System	<ul style="list-style-type: none"> <li>• Software engineering approaches</li> <li>• Functional, multiagent systems</li> <li>• Nonfunctional: Flexibility, autonomy, adaptive...</li> </ul>	<ul style="list-style-type: none"> <li>• Statistics</li> <li>• Artificial intelligence/machine learning</li> <li>• Database</li> <li>• Visualization</li> </ul>
Techniques	<ul style="list-style-type: none"> <li>• Logic-based</li> <li>• Software engineering based</li> <li>• Artificial intelligence-based</li> <li>• Social sciences based</li> </ul>	<ul style="list-style-type: none"> <li>• Statistics</li> <li>• Artificial intelligence/machine learning</li> <li>• Database</li> <li>• Visualization</li> </ul>

# Strengths complementation

- Agent → data mining: software engineering, infrastructure, human-mining interaction, decision making, etc.
- Data mining → agent: data exploration, analysis, knowledge, learning, etc.



# Overview of AMII Research and Development

## Content

- ❑ What is AMII/ADMI
- ❑ AMII aims and objectives
- ❑ Evolution briefing
- ❑ Research groups & projects
- ❑ Professional activities

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## Research aims and objectives

- a) Identify **challenges and directions** for the synergy between agents and data mining
- b) Exploit **agent-enriched data mining** demonstrate how agent technology can contribute to critical data mining problems in theory and practice;
- c) Improve **data mining-driven agents** show how data mining can strengthen agent intelligence in research and practical applications;
- d) Explore the integration of agents and data mining towards a **super-intelligent system**;
- e) Develop **project methodology, specifications and programming techniques** for handling workable applications

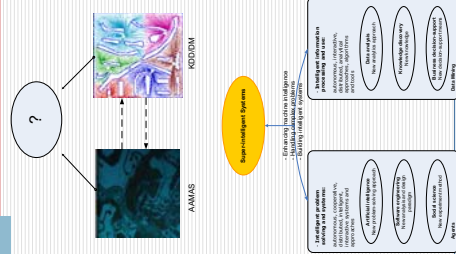
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## Agent-mining interaction & integration

- ❑ Key factors
    - Entities
    - "agent" + "mining"
    - Features
- autonomous, flexible, adaptive, interaction, analysis, learning, reasoning, decision-making, ...
- Benefits: super-intelligent systems



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## Evolution briefing

- ❑ Started from early 1990's
- ❑ Pioneering papers in **1991**
  - Sian, S. "Extending Learning to Multiple Agents: Issues and a Model for Multi-Agent Machine Learning (MA-ML)", In *Proceedings of the European Workshop Sessions on Learning EWSL91*, Kodratoff, Y., Springer-Verlag, Porto, Portugal, 1991, pp. 458-472.
  - Brazdil, P. & Muggleton, S. "Learning to Relate Terms in a Multiple Agent Environment", *EWSL91*, 1991
- ❑ Agent-based data mining & knowledge discovery by Davies, W., 1994
- ❑ Related topics in workshop since 2000
- ❑ Specific **workshops** started in 2005
- ❑ **Special issue** from 2006
- ❑ More activities, more interest attracted, more publications, more applications, e.g., **AIS-ADM07**, **ADMI07**, ...

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## Two major communities

- AAMAS
- Multiagent learning
- Distributed multi-agent learning
- ...
- KDD & DM
- ICDM: Data mining in multi-agent data
- Agent-based distributed data mining
- Agent-based peer-to-peer data mining
- ...

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## Research projects

- ILS [Silver:90]
- GOLEM and INTEG.3 [Brazdil and Muggleton, 1991]
- ANIMALS [Davies:93, Edwards:93]
- MALE [Sian, 1991]
- Carnot [Woelk et al., 1992]
- PADMA (Parallel Data Mining Agents) [Kargupta, 1997]
- JAM (Java Agents for Metalearning) [Stolfo, et al, 1997]
- Papyrus [Bailey, 1999]
- BODHI [Kargupta, 2000]
- OPS [Gorodetski, 2000-05]
- AA-2.0 (Agent Academy) [Mitkas, 2002-06]
- F-Trade (Autonomous financial data mining) [Cao and Zhang, 2003-06]
- Agent-based data mining and warehousing (US Patent) [Weiss, Michael; Mankovskii, Serguei, 2005]
- OWLS-MX (Hybrid Semantic Web Service Retrieval) [Klusch, 2005]
- P2P agent platform (Vladimir Gorodetsky)
- .....

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## Research groups

- Andrew G. Barto, USA
- Longbing Cao, Australia
- Elizabeth Chang, Australia
- Winton Davies, Australia
- John Debenham and Simeon Simoff, Australia
- Vladimir Gorodetski, Russia
- Stephen Haag
- Hillol Kargupta, USA
- Daniel Kludenko, UK
- Matthias Klusch, Germany
- Jiming Liu, Canada
- Sridhar Mahadevan, USA
- Vladimir Malik, Czech
- Pericles A. Mitkas, Greece
- Kusunuma, Y.; Hijikata, Y. and Nishida, S
- Mohammadian, M. and Jentzsch, R
- Joerg Muller, Germany
- Eugenio Oliveira, Portugal
- Zbigniew Ras, USA
- Sandip Sen, USA
- Zhong Zhi Shi, China
- Victor Skormin, UK
- Andrzej Skowron, Poland
- Salvatore Stolfo, USA
- Peter Stone, USA
- Katia Sycara, USA
- Gerhard Weiss, Austria
- Chengqi Zhang, Australia
- Zili Zhang, China
- Ning Zhong, Japan
- .....

- **Loosely, separately:** Over 30 groups involving research on both agents and mining
- **Tightly, interactively:** Only a few of groups study agent & mining interaction and integration

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## AMII Research Issues

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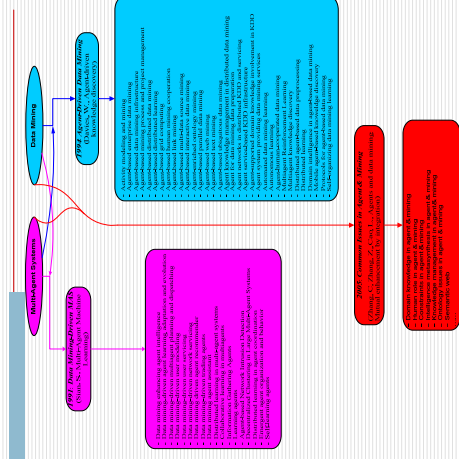
- Topic evolution
- Agent driven data mining
- Data mining driven agents
- Mutual issues

■ **Super-intelligent symbionts**

# Agent driven data mining

- Activity modeling and mining
- Agent-based enterprise data mining
- Agent-based data mining infrastructure
- Agent-based mining process and project management
- Agent-based distributed data mining
- Agent-based distributed learning
- Agent-based grid computing
- Agent-based human mining cooperation
- Agent-based link mining
- Agent-based multi-data source mining
- Agent-based interactive data mining
- Agent-enriched ontology mining
- Agent-based parallel data mining
- Agent-based web mining
- Agent-based text mining
- Agent-based ubiquitous data mining
- Agent-based peer-to-peer mining

# Topic evolution



# Agent driven data mining

- Agent knowledge management in distributed data mining
- Agent for data mining data preparation
- Agent networks in distributed knowledge discovery and servicing
- Agent service-based KDD infrastructure
- Agent-supported domain knowledge involvement in KDD
- Agent system providing data mining services
- Automated data mining learning
- Autonomous learning
- Agent-human-cooperated data mining
- Multiagent Reinforcement Learning
- Multiagent knowledge discovery
- Distributed agent-based data preprocessing
- Distributed learning
- Domain intelligence in agent-based data mining
- Mobile agent-based knowledge discovery
- Protocols for agent-based data mining
- Self-organizing data mining learning
- 
-

## Data mining models as agents

- Intelligent data mining agents – modeling data mining algorithms as agents
- Data mining model integrator – integrating data mining algorithms
- Data mining model planner – smartly managing data mining algorithms
- Data mining model recommender – recommending appropriate algorithms

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## User and interaction agents for data mining

- Human agent interaction for data mining
- Agents for interactive mining
- Agents in human-guided mining
- Domain knowledge management using agents
- User agents for preparing mining reports
- Agents for circulating mining results

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## Agent-based management of distributed and multiple data sources

- Data gateway agents for connecting data sources
- Distributed data preprocessor agent
- Data integrator agents for data integration
- Agents for data clustering
- Agents for ensemble mining in distributed data
- Agents for data sampling and assumption

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## Data mining driven agent

- Data mining enhancing agent intelligence
- Data mining-driven agent learning, adaptation and evolution
- Data mining-driven multiagent communication, planning and dispatching
- Data mining-driven user modeling
- Data mining-driven user servicing
- Data mining-driven network servicing
- Data mining driven agent recommender
- Data mining-driven trading agents
- Data mining agent assistant
- Distributed learning in multi-agent systems
- Collaborative learning in multiagents
- Information gathering agents
- Learning agents
- Agent-based network intrusion detection
- Decentralized Clustering in Large Multi-Agent Systems
- Distributed learning in agent coordination
- Emergent agent organization and behavior
- Self-learning agents
- .....

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## Data mining-driven agent learning

- DM-driven learning in MAS
  - Coordination learning
  - Self/individual learning
  - Group/collective learning
  - Distributed learning
  - Dynamic learning
  - Online/offline learning

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## Data mining for agent communication, planning and dispatching

- Class/segment-based communication
- Association, correlation, cluster and classification based planning, reasoning, dispatching
- Class-based planning and dispatching
- Data mining based agent service discovery, location and transport
- Optimizing agent services

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## Data mining-driven evolution and adaptation in MAS

- Evolution of MAS based on hidden rules, so mine these rules and fill into the agent knowledge base for designing evolutionary agent systems
- Adaptive capability mining for enhancing agent's adaptation
- Self-organization rule mining

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## Mutual issues

- Domain intelligence
  - Domain knowledge
  - Expert knowledge
  - Imaginary thinking
  - Representation, transformation, mapping
- Business knowledge
  - Organizational factors
  - Business logics
  - Business interest

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- Human intelligence
- Human role
- Stakeholder characteristics
  - Business, technical, financial, etc.
  - User modeling, profiling
  - User preference
- Qualitative intelligence
  - Thinking, imagination, recognition, etc.
- Ad hoc intelligence
  - Reasoning
- Expert understanding
  - Supervised, semi-supervised
  - Business understanding
  - Data understanding

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- Agent-mining symbiont model
  - Attributes, properties
  - Infrastructure and architecture problems
  - Human-agent, agent-mining interaction
  - Agent-mining lifecycle definition and management
  - Agent-mining behavior pattern, scenario analysis and management
  - Service management
  - Knowledge management
  - Intelligence meta-synthesis
    - Agent intelligence
    - Data mining/data intelligence
    - Human intelligence
    - Domain intelligence
    - .....

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- Social intelligence
  - Social factors
    - Privacy, security, trust
    - Policy, law, rule, norm
  - Constraints
    - Data constraints
    - Domain constraints
    - Knowledge constraints
  - Deliverables
    - Deliverable constraints
    - Quality: Dependability, operationalisability, actionability

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- Performance and evaluation
  - Functional issues
    - Intelligence enhancement
    - Knowledge enhancement
    - Computing enhancement
  - Nonfunctional issues
    - Actionable capability
    - Security
    - Privacy
    - Trust
    - Dependability
    - Scalability ...
  - Performance evaluation
    - Evaluation framework and metrics
      - Functional vs. nonfunctional
      - Technical vs. business
      - Subjective vs. objective
      - Individual vs. integrative
      - Conflict resolution
    - Verification and validation ...
  - Project benefit-risk management

Phase4:  $\forall s, X, Z, \text{res}, \text{exp}_s, \text{obj}(e) \in \text{res}, \text{obj}(e) \in \text{obj}_s$   
 $\text{obj}(e) \in \text{obj}_s \rightarrow \text{obj}(e) \in \text{obj}_s$

Scenario	Relationship	Explanation
S1	$\text{res}_s, \text{obj}(e) \in \text{obj}_s$	A pattern $e$ does not satisfy technical significance but satisfies business expectations.
S2	$\text{obj}_s, \text{obj}(e) \in \text{obj}_s$	A pattern $e$ satisfies technical significance but not business expectations.
S3	$\text{res}_s, \text{obj}(e) \in \text{obj}_s$	A pattern $e$ satisfies business expectations as well as technical significance.
S4	$\text{obj}_s, \text{obj}(e) \in \text{obj}_s$	A pattern $e$ satisfies neither business expectations nor technical significance.

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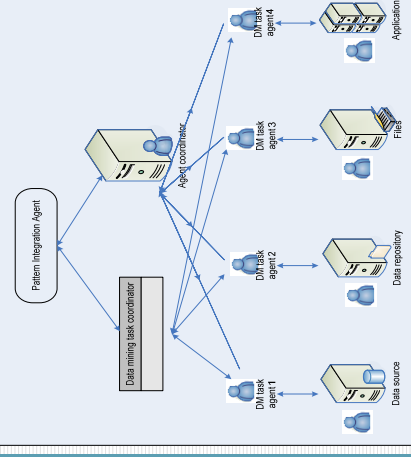
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# AMII Approaches and Techniques

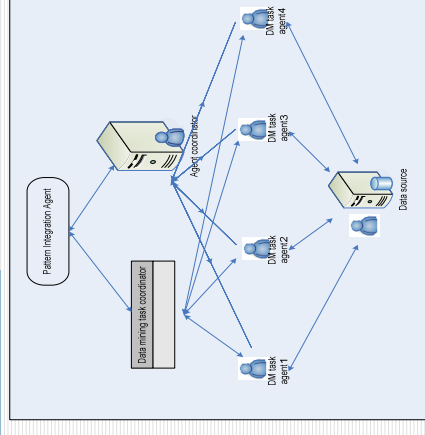
# Contents

- Agent-based distributed data mining
- Peer-to-peer data mining
- Agent-based data mining infrastructure
- DM-driven agent servicing
- Ontology-based integration



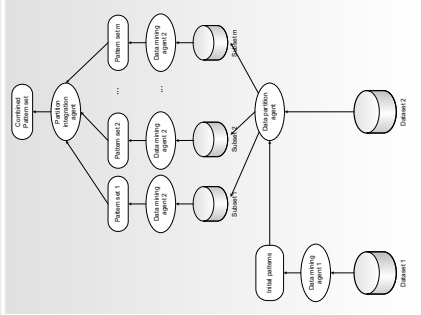
- Agent-based distributed data mining**
- Multiple data sources:
    - ~ distributed
    - ~ heterogeneous
  - Multiple DM task agents:
    - ~ conduct individual tasks
    - ~ coordinate by agent coordinator and data mining task coordinator
  - Pattern integration:
    - ~ pattern integration agent
    - ~ final integrative patterns

- Agent-based multiple data mining task integration**
- One data source:
    - ~ single
    - ~ homogeneous
  - Multiple DM task agents:
    - ~ conduct individual tasks
    - ~ coordinate by agent coordinator and data mining task coordinator
  - Pattern integration:
    - ~ pattern integration agent
    - ~ final integrative patterns

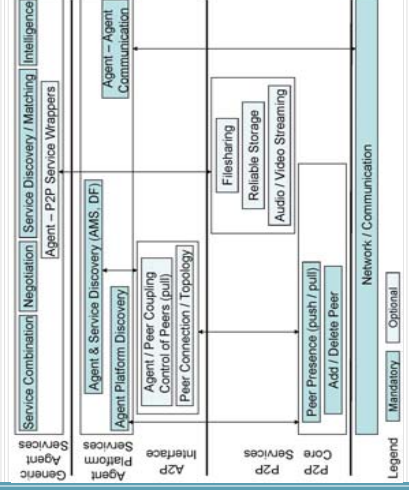


**Agent-based combined pattern mining**

- Multiple data sources:
  - ~ distributed
  - ~ heterogeneous
- Multiple-step data mining:
  - ~ initial pattern mining on DS1
  - ~ 2<sup>nd</sup> pattern mining on DS2 ~ DS<sub>m</sub>
  - ~ pattern combination
- Pattern integration:
  - ~ pattern integration agent
  - ~ final combined patterns



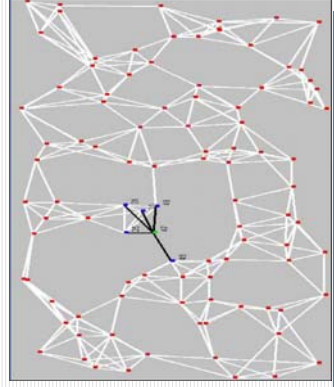
# Basis: Functional Architecture Proposed by FIPA Nomadic Agent Working Group



- Bottom layer - P2P provider ("Peer")**
- **P2P core**, a sub layer implementing "peer presence" mechanism, indicating whether a network peer is currently connected to the network and **mechanism** for management by its **contact list** (add, delete neighbors).
  - **P2P services**, a sub layer containing some optional functionalities of the peer.
- Intermediate layer - P2P agent platform (agent-to-peer platform)**
- **Agent platform services**, a sub layer including **FIPA yellow pages (DF)** and **white pages (AMS)** services supporting **discovery of agents and agent platforms**, and **Agent-to-Agent communication mechanism (MTS, ACL)**.
  - **A2P Interface** implementing interaction between agent platform and peer.
- Top layer**
- Corresponds to FIPA agent services.

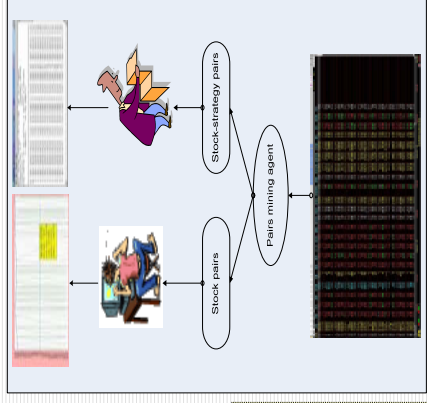
## Agent-based peer-to-peer data mining

- P2P data mining
  - P2P computing
  - Communication
  - Storage
  - Human-computer interaction
- FIPA Nomadic Agent Working Group



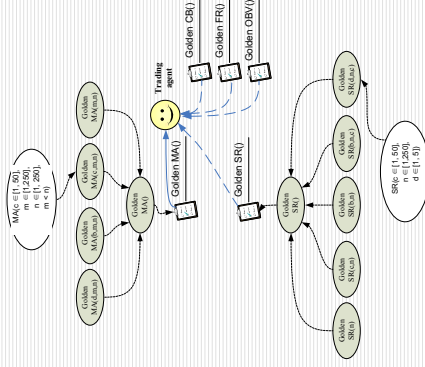
## DM-based agent servicing

- DM-based recommender agents
  - Stock recommender
  - In-depth rule recommender
  - Trading rule-stock recommender



## DM-based trading agents

- Classify trading strategies
- Identify golden intra-class trading strategies
- Identify golden inter-class trading strategies
- Trading agent actions



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## DM-based user modeling

- Analyzing user behavior for agent design
  - Game player modeling
  - Trading agent's behavior modeling
  - Trading agent's role modeling
- User-agent interaction based on user modeling
  - Trading agents' interface design
  - Trader-agent interaction rule design

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## Agent-based data mining infrastructure

- Human-agent interaction support tool
- Agent-based software engineering
- Multi-agent design support
- Data management support
- Data preparation support
- Data mining agent support
- Pattern management
- Agent training & testing
- Agent behavior lifecycle support
- Agent management
- Reporting & presentation
- Evaluation metrics for agent-mining symbiont
  - Agent intelligence
  - Agent knowledge actionability

- Ontology service based management
  - Management purpose
  - Syntactic
  - Semantic
- Agent services based implementation
  - Implementation purpose
  - Registration, transport, discovery, ...

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## Ontology-based agent mining symbiont

- Ontology for organizing agent systems
- Ontology for organizing mining algorithms
- Ontology for user interaction
- Managing domain ontology/task ontology/problem-solving ontology/method ontology
- Ontology for data management
- Ontology for service management
- Ontology for knowledge/pattern management
- Ontology for agent-mining lifecycle management
- Ontology for input/output management

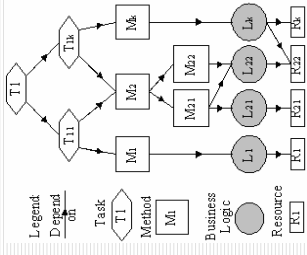
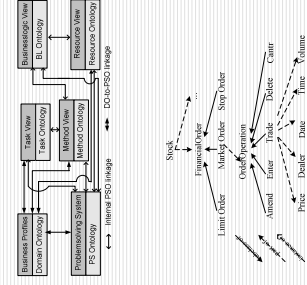
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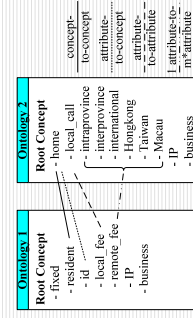
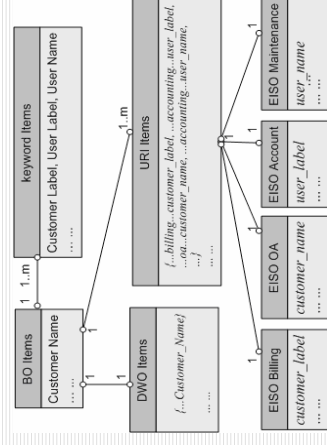
# Ontological engineering for the integration

- Ontological specifications
  - Ontology namespace
  - Ontology mapping structure
  - Semantic relationship management
  - Semantic rules for ontology mapping
  - Ontology transformation
  - Ontology query
  - Ontology search and discovery



# Ontology-based system architecture

- Multi-domain ontological space
  - Related problem domains
  - Agent ontology domain
  - Data mining ontology domain
- Hybrid ontology structure for organizing ontologies crossing multiple domains
  - Domain ontology for understanding the domain problems
  - Problem-solving ontology
  - Task ontology
  - Method ontology



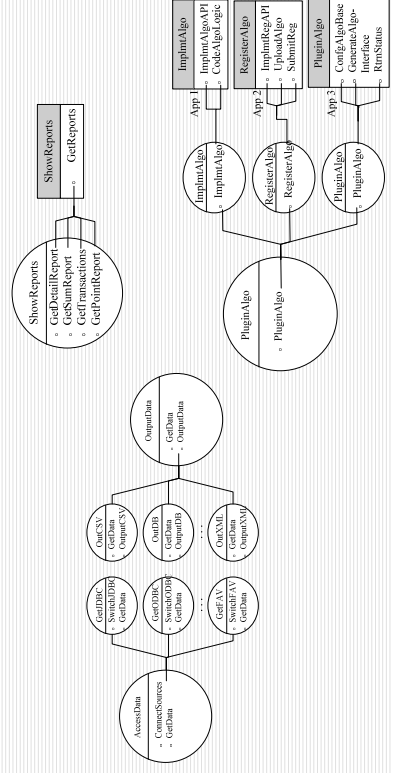
Rule 4.  
 $\forall (A \text{ AND } B), \exists B' := \text{substitute\_} \alpha(A, B)$   
 $\Rightarrow A \text{ OR } B'$ , the resulting output is  $A \text{ or } B'$

Rule 5.  
 $\forall (A \text{ AND } B), \exists B' := \text{disjoint\_} \alpha(A, B)$   
 $\Rightarrow A \text{ AND } B'$ , the resulting output is  $A \text{ and } B'$

**Develop ontology services**

- Semantic mapping rules
- Ontology transformation rules
- Service discovery

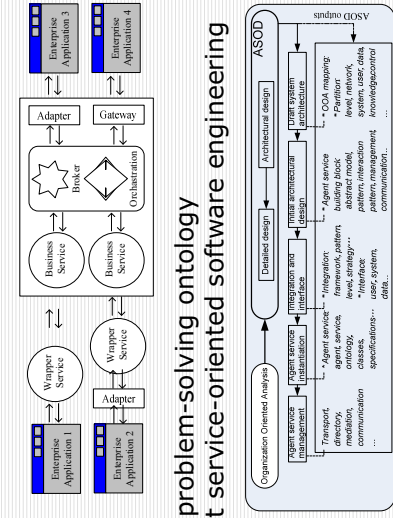
Agent service interface design



Agent service based implementation

- Agent service model
- Service properties
- Agent service architectural patterns
- Agent service functional patterns

Agent service-based integration architecture





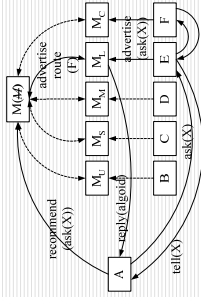
Agent service management

- Registration
- Directory
- Transport
- Discovery
- Coordination

```
public interface AgentServiceLocator {
    int hashCode();
    String getType();
    String getAddress();
    setType(String type);
    void setAddress(String address);
}
```

```
public interface AgentDirectory extends Directory {
    AgentDescription[] getAgentDescription();
    Vector getDirectoryEntry();
    void register(AgentDescription ad) throws DirectoryFailure;
    void update(AgentDescription ad) throws DirectoryFailure;
    void delete(AgentDescription ad) throws DirectoryFailure;
    AgentDescription[] search(AgentDescription ad) throws DirectoryFailure;
    void setDirectoryEntry(Vector de);
}
```

```
public interface AlgoAgentInterface {
    void setParameter(String parameterName, String value) throws TradeException;
    void execute() throws TradeException;
    String getResult(String outputString) throws TradeException;
    void setDatabaseDriver(String driver) throws TradeException;
}
```



# AMII Applications and Case Studies

# Application areas

- Financial & economic areas
  - Auction
  - Mechanism design
  - Trading strategy development in artificial stock markets
  - Finance data mining
  - Supply chain management
  - Trading agents
- Simulation and backtesting
  - Artificial Immune Systems
- Business areas
  - Business intelligence
  - Customer relationship management
  - e-commerce
  - Supply chain management
- Networks
  - Internet & social intelligence & social network analysis
  - Network intrusion detection
  - Network services, eg., recommendation, personal assistant, searching, retrieval, extraction
  - Web & text mining
- Computational intelligence
  - Distributed data extraction and preparation
  - Grid computing
  - Parallel computing, eg., parallel GA
  - Peer-to-peer
- Knowledge engineering
  - Knowledge management
  - Semantic web
  - Ontological engineering



## Case studies

- F-Trade 2.0
- P2P Agent Platform
- Agent Academy-2

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## F-Trade functions

- Support Trading,
  - e.g., identifying better trading rules
- Support Surveillance,
  - e.g., identifying exceptional trading behavior
- Support Data Mining,
  - e.g., developing actionable trading strategies
- Support Agents,
  - e.g., developing multi-trading agent learning

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## F-Trade

F-Trade 2.0 (Financial Trading Rules  
Automated Development and Evaluation)  
-- An Agent-Mining Symbiont for Financial Services  
([www.f-trade.info](http://www.f-trade.info), [www.ftrade.info](http://www.ftrade.info))

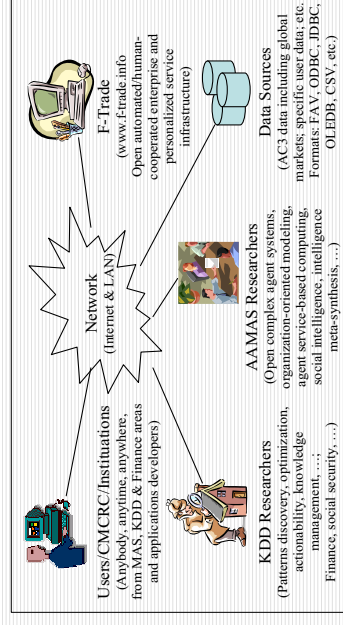
Longbing Cao, Chengqi Zhang  
Faculty of Information Technology  
University of Technology Sydney, Australia

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## Organizational scheme



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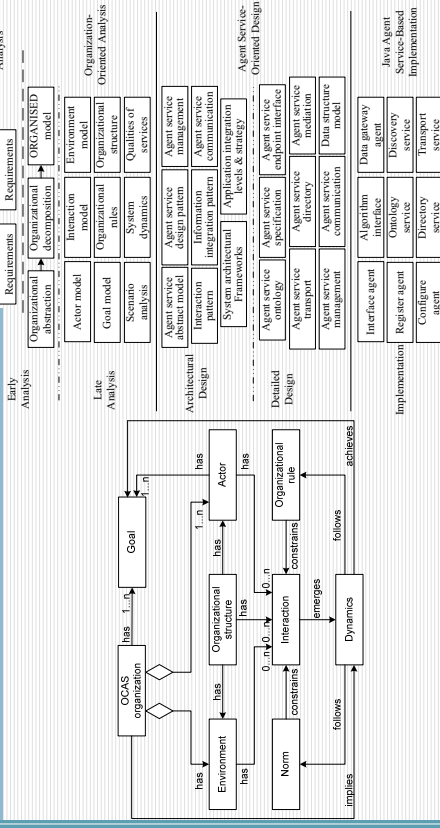
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# System environment

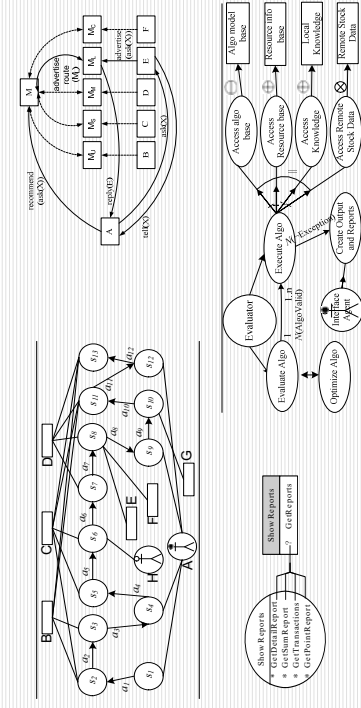
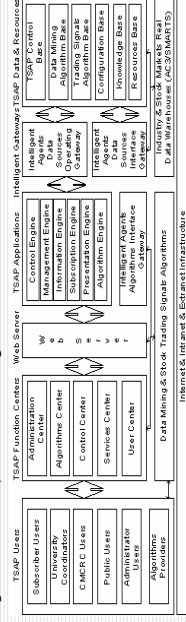
- Data
  - Global market orderbook data (tick-by-tick & daily)
  - AC3, CMCR, SIRCA Ltd.
- Implementation
  - Web-based
  - Java, C, XML, SQL
  - Unix, Linux, Windows
  - App server (UTS) + database server (UTS) + data warehouse (AC3) + browsers
- Trading rules/strategies
  - Brokers/firms/financial researchers/data mining
- System history
  - TSAP 1 (2003) → F-Trade 2 (2004) → F-Trade 3 (coming)

# OSOAD



# Agent-based data mining infrastructure

- Software engineering of open complex agent systems
- Organization and Service Oriented Analysis and Design
  - Organizational abstraction
  - Agent service-oriented design
- Agent service-based plug-n-play
  - Agent service-based system modules and services
  - Agent-based trading rules, DM algorithms
  - Remote data access, message passing, transactional processing, data sources
- Agent ontology-based management
  - Ontology for managing modules, algorithms, data sources, users
  - System reconstruction, personalization, customization
  - Human-agent interaction, interface management



```

□ <S> RegisterAlgorithm: register(ParaArrayList)
<SO> ServiceOwner: PLUGINPERSON </SO>
<ST> ServiceType: Action </ST>
<SL> SenderLocator: AgentTransport.getSender()</SL>
<RL> ReceiverLocator: AgentTransport.getReceiver()</RL>
<I> InputVariables: AlgoInterface.getParameter()</I>
<IC> Preconditions: AlgoInterface.getInConstraint()</IC>
<O> OutputVariables: AlgoInterface.getResult()</O>
<OC> Postconditions: AlgoInterface.getOutConstraint()</OC>
<IO> SemanticRelation: one-one</IO>
<TT> TransType: AgentTransport.getTransportType()</TT>
<TA> TransAddress: getTransportAddress()</TA>
<TM> TransMessage:
AgentTransport.getTransportMessage()</TM>
<E> Exception: FTradeException </E>
□ </S>

```

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## Agent-driven data mining

- Agent service-based infrastructure
- Agentized trading rules and algorithms
- Agent ontology for rule/algorithm registration, in/out interface generation, etc
- Agentized rule/algorithm recommendation, subscription, reporting
- Message passing, request/response, dispatching among rules, interfaces, resources, reports, users

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## Control center

**F-TRADE Function Tree Configuration**

Current Time ID	Current Time Base	Current Action	Action Type	Subtree Base	Action URL	Action Type
1	Parameterize	Parameterize	Parameterize	Parameterize	Parameterize	Parameterize

**Introduction**

This is a web-based platform (F-TRADE) used to evaluate Stock Trading Signals and data mining algorithms. This platform is built on the huge historical and real stock information. It can be logged on from anywhere at anytime after register.

Individual investors can choose any built-in trading algorithm (or strategy) for any stock they choose to evaluate the performance of your strategy in history. The users can try to set different values for the parameters to find out the best combination for the best performance of the strategy.

Besides the above function, investors can build your own trading algorithms to upload to the platform online for your private use to evaluate the performance. You can benefit from the huge historical real stock information under the platform. You can also benefit from the testing to find the best combination of the parameters.

The F-TRADE platform includes five centers which are: **Center: Algorithm center**, **Center: Administration center**, **Center: Control center**, and **Center: Service center**. For the new users, please click ["New Manual"](#) to read online user manual. For the experienced users, please click the relevant functional icons in the left column. For the inquiry, please send email to the [Web Master](#).

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## Agent-driven data mining

- Agent service-based infrastructure
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# Trading strategies of trading agents



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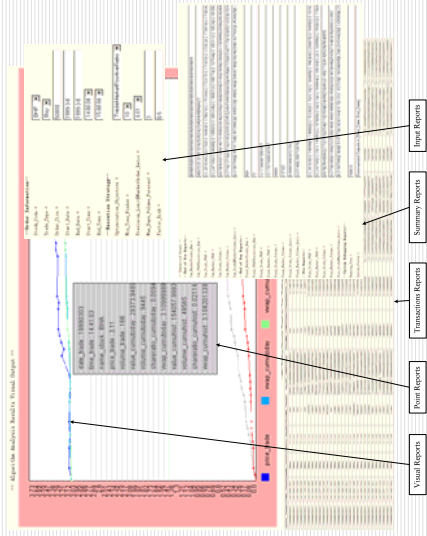
# Data mining-driven trading agents

- Data mining based trading rule agents
- KDD-driven trading agent optimizers with better rules and higher performance
- Mining actionable trading rules for trading agents in generic trading pattern set
- Parameter tuning of trading rule agents
- Trading rule recommenders
- Trading user assistants with better trading strategies

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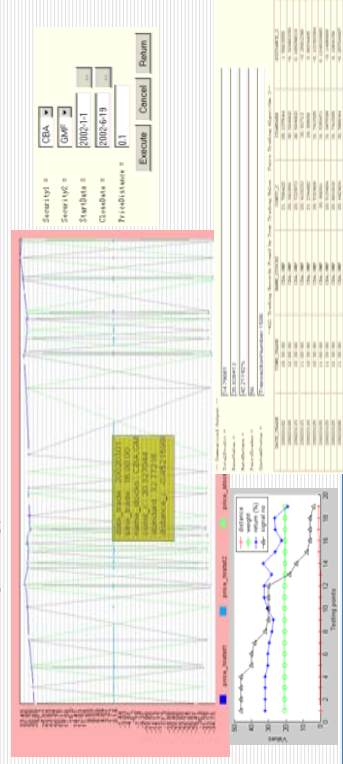


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- Pairs mining based trading agent
  - Mining correlated stock pairs
  - Correlated stock miner agent
  - Stock pairs recommender
  - Pairs trading strategy solution



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- Optimized trading strategies for trading agents
  - Mining in-depth rules
  - In-depth rule miner agent
  - User interface agent
  - Optimized rules recommender
  - Optimized trading strategy solution

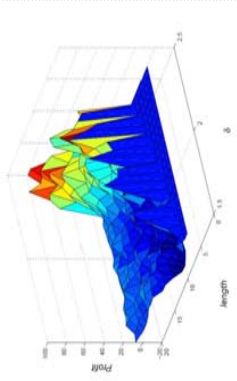


Figure 1.1: Profit landscape of Bollinger Bands strategy

- Enhancing actionability of trading strategy for trading agents

$$\Omega = \{e_1, e_2, \dots, e_m\}$$

$$= \{(t, b, p, v, i) \mid t \in T, b \in B, p \in P, v \in V, i \in I\}$$

$$\begin{cases} tech\_int(t, b, p, v, i) \rightarrow \max[tech\_int()] \\ biz\_int(t, b, p, v, i) \rightarrow \max[biz\_int()] \end{cases}$$

$$Q = \{(\theta, \delta) \mid \theta \in \Omega, \delta \in \{(\delta_1^k, \delta_2^k) \mid \delta_1^k \in \sum_{a \in A} a\}\}$$

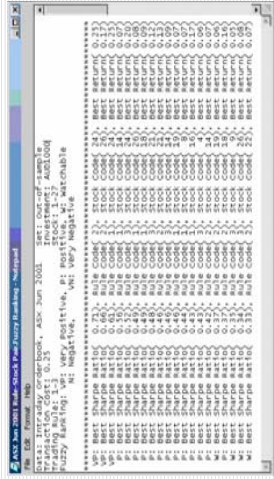
$$\Sigma = \{\delta_1^k \mid a \in C, k \in N\}$$

$$\forall x \in X: \exists x: x: tech\_obj(\theta) \wedge x: tech\_obj(\delta) \wedge biz\_obj(\theta) \wedge biz\_obj(\delta) \rightarrow x: act(\theta)$$

$$TR = \left( \sum_{i=1}^n AskPrice_i * AskVolume_i - \sum_{i=1}^n BidPrice_i * BidVolume_i \right) / TotalInvestment$$

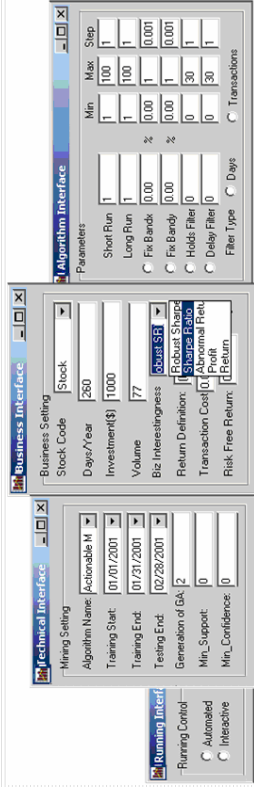
$$IR = \left( \sum_{i=1}^n (Index_{X,i} - Index_X) \right) / n$$

- Rule-stock pairs for trading agents
  - Mining rule-stock pairs
  - Rule-stock pair mining agent
  - User interface agent
  - Rule-stock pair recommender
  - Trading strategy solution

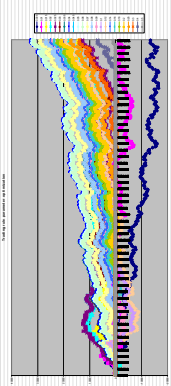


Agent service interfaces:

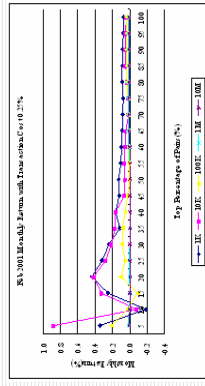
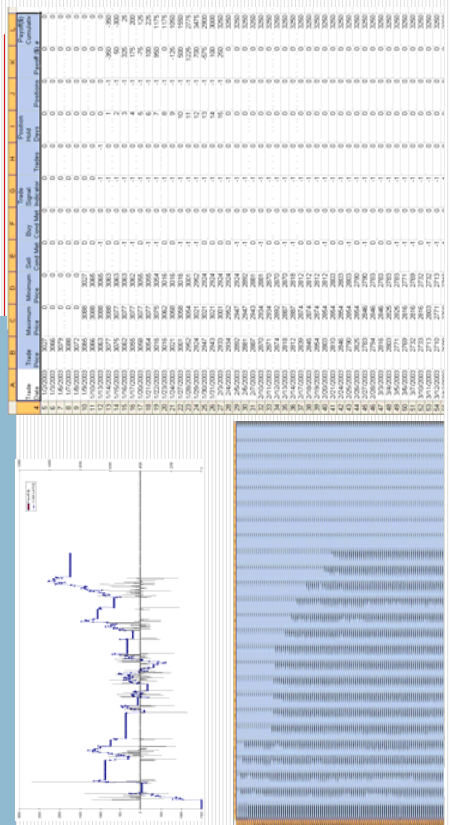
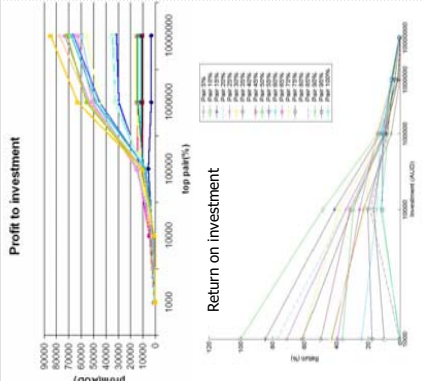
- Business interfaces supporting business users' interaction with the system;
- Technical interfaces supporting domain expert's interaction with the system;
- Algorithm interfaces supporting algorithm designer's interaction with the system;
- Running interfaces supporting system execution control.



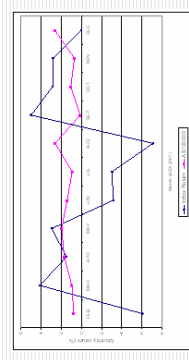
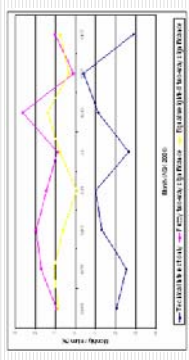




Develop optimized trading strategies for trading agents:  
 - Optimized trading strategies  
 - Checking business performance:  
 - Actionability of trading strategies



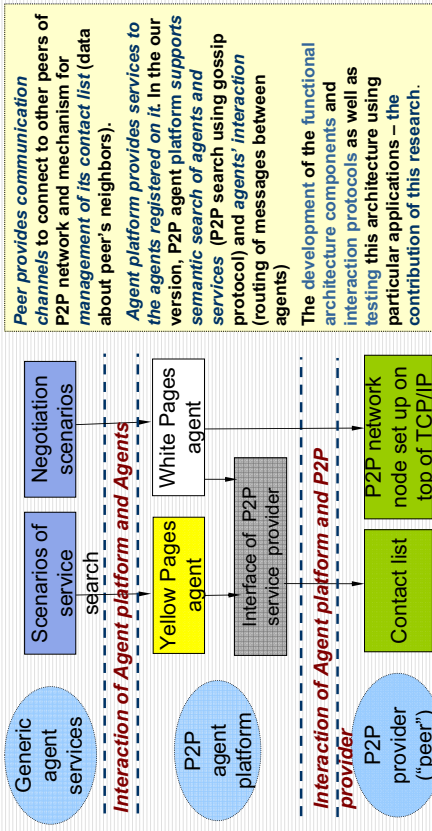
Trading strategy-stock pairs agent  
 Actionability enhancement  
 - Technical interestingness only  
 - Two-way significance  
 ~ technical significance  
 ~ business preferences  
 - Fuzzy two-way significance  
 Checking business performance:  
 - beating market



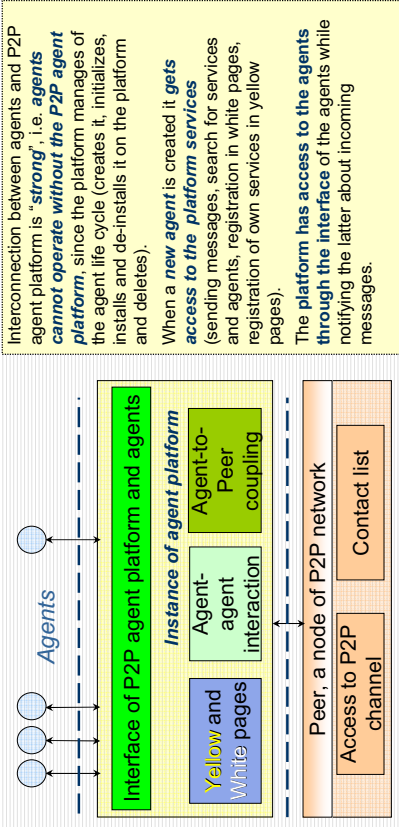
## P2P Agent Platform

V. Gorodetsky, O.Karsaev, V.Samoylov, S.Serebryakov  
 St. Petersburg Institute for Informatics and Automation  
 Laboratory of Intelligent Systems  
<http://space.ias.spb.su/ap/index.php?menu=home>

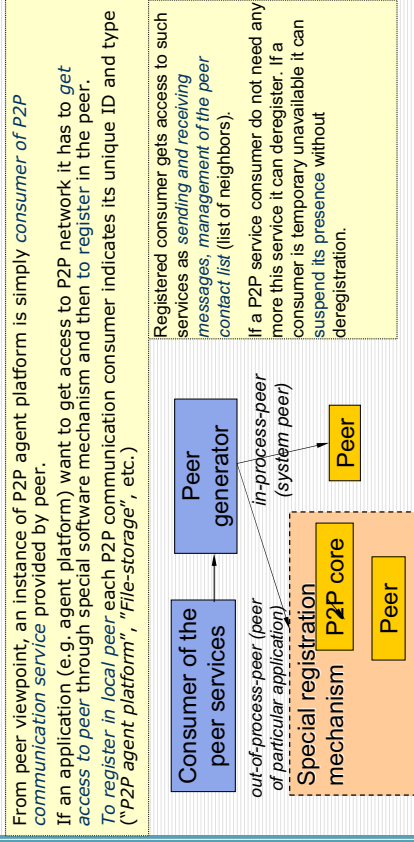
# Functional Architecture of the Developed P2P Agent Platform and P2P Provider



# Interaction of Agents and P2P agent Platform



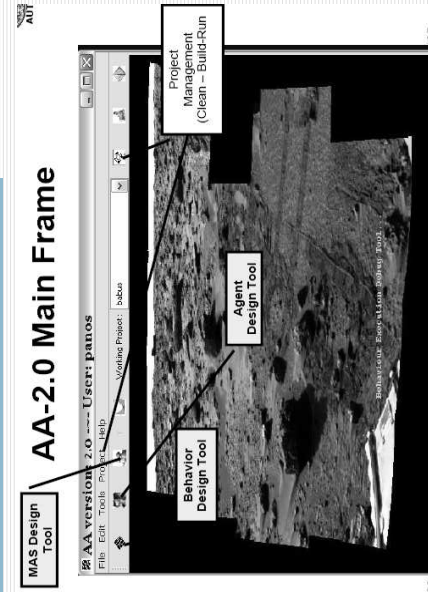
# Interaction of P2P Agent Platform and P2P Provider



# An integrated tool for embedding data mining extracted intelligence into agents is Agent Academy (AA):

<http://sourceforge.net/projects/agentacademy>

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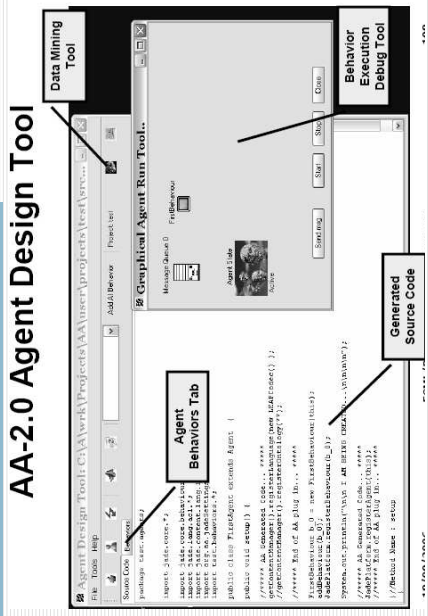


## AA-2.0 Main Frame

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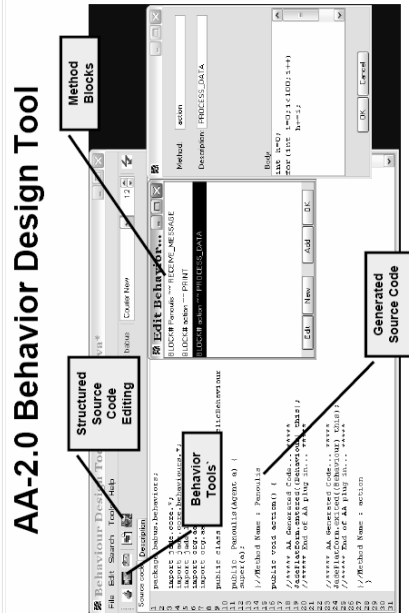


## AA-2.0 Agent Design Tool

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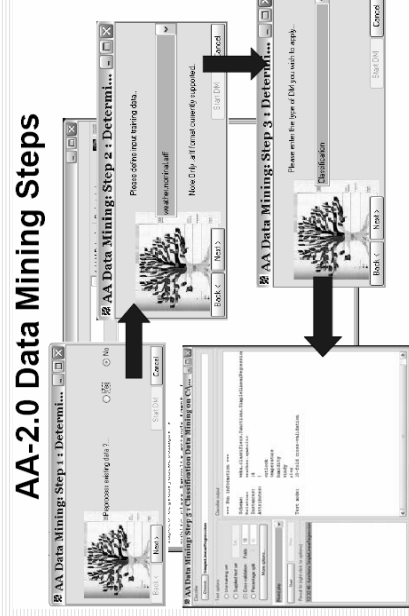


## AA-2.0 Behavior Design Tool

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## AA-2.0 Data Mining Steps

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## AMII References and Resources

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## Relevant activities

- Workshops
  - **ADMI2007** (*Agents and Data Mining Interaction*, Petcules A. Mitkas, Longbing Cao, Vladimir I. Gorodetski, Justin Zhan)
  - **AISADM2007** (Vladimir I. Gorodetski, Chengqi Zhang, Victor Skormin, Longbing Cao)
  - **ADMI2006** (*Agents and Data Mining Interaction*, Longbing Cao, Zili Zhang, Vladimir I. Gorodetski)
  - **AISADM2005** (*Autonomous Intelligent Systems: Agents and Data Mining*, Vladimir I. Gorodetski, Jiming Liu, Victor Skormin)
  - **MADW-MADM2005** (*Multiagent Data Warehousing and Multiagent Data Mining*, Wen-Ran Zhang, Yan-Qing Zhang, Xiaohua Tony Hu)
  - **ALAMAS** workshop series in 2000-2004 (Adaptive Agents and Multi-agent Systems, by Daniel Kudenko)
- Special issue
  - Interaction between Agents and Data Mining (Guest editors: Longbing Cao, Zili Zhang, Vladimir I. Gorodetski, Chengqi Zhang)

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## Books

- Books
  - L. Cao, R. Dai. *Open Complex Intelligent Systems*, Posts & Telecom Press, 2007.
  - A. Symeonidis, P. Mitkas, *Agent Intelligence through data mining*, Springer, 2005.
- Proceedings
  - P. Mitkas, L. Cao, V. Gorodetsky (Eds.). *ADMI2007 Proceedings*, IEEE CS Press, 2007.
  - V. Gorodetsky, V. Skormin, C. Zhang, L. Cao (Eds.). *AISADM2007 Proceedings: Autonomous intelligent systems: agents and data mining*, Springer, 2007
  - L. Cao, Z. Zhang, V. Gorodetsky (Eds.). *ADMI2006 Proceedings*, IEEE CS Press, 2006.
  - V. Gorodetsky, J. Liu, V. Skormin (Eds.). *AISADM2005 Proceedings: Autonomous intelligent systems: agents and data mining*, LANI 3505, Springer, 2005

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## Publication

- Summary
  - More publications emerged after 2000
  - Over 130 papers searchable
  - 6 books/proceedings
- Pioneering work
  - Sian S. "Extending Learning to Multiple Agents: Issues and a Model for Multi-Agent Machine Learning (MA-ML)", in *Proceedings of the European Workshop Sessions on Learning EWSL91*, Kodratroff, Y., Springer-Verlag, Porto, Portugal, 1991, pp. 458-472.
  - Brazdil, P. & Mugletori, S. "Learning to Relate Terms in a Multiple Agent Environment", *EWSL91*, 1991
  - Davies, W., "ANIMALS: A Distributed, Heterogeneous Multi-Agent Learning System", MSc Thesis, University of Aberdeen, 1993.
  - Edwards, P. & Davies, W. "A Heterogeneous Multi-Agent Learning System", In *1993 Proceedings of the Special Interest Group on Cooperating Knowledge Based Systems*, Deen, S.M., University of Keele, 1993, pp. 163-184.
  - Davies, W., "Agent-Based Data-Mining", 1994

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# Publication

- Introduction to AMII
  - Longbing Cao, Chao Luo and Chengqi Zhang. *Agent-Mining Interaction: An Emerging Area*, AISADM07 (<http://space.ilas.spb.su/ais07/presentations/cao.pdf>)
  - Longbing Cao, Zili Zhang, Vladimir Gorodetsky, Chengqi Zhang. Editor's Introduction: Interaction between agents and data mining, International Journal of Intelligent Information and Database Systems, 1(4), 2007.
  - Longbing Cao, Chengqi Zhang. F-Trade: An Agent-Mining Symbiont for Financial Services, AAMAS2007.
  - Longbing Cao, Chao Luo, Chengqi Zhang. Agent-Mining Interaction: An Emerging Area, AIS-ADM07, LNAI4476, 60-73, Springer, 2007.
  - Zhang, C.; Zhang, Z. and Cao, L.: *Agents and Data Mining: Mutual Enhancement by Integration*. Autonomous Intelligent Systems: Agents and Data Mining Volume, LNAI3505
  - Ong, K.; Zhang, Z. and Ng, W.; Lim, E.: *Agents and stream data mining: a new perspective: intelligent systems*, IEEE Press on IEEE Intelligent Systems and their Applications Volume 20; Issue 3; May-June 2005. Page(s):60 - 67. 2005
  - Cao, L.: *Integration of Agent and Data mining*, 25 June 2005 (<http://www.staff.it.us.edu.au/~lbcao/publication/Integration%20of%20Agent%20and%20Data%20Mining.ppt>)

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2007

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- Agent-driven data mining
  - Zhang, Z. and Zhang, C.: *Agent-Based Hybrid Intelligent System for Data Mining*, Agent-Based Hybrid Intelligent Systems Volume 2938/2004 2004 Lecture Notes in Computer Science
  - Patel, M. and Duke, M.: *Knowledge Discovery in an Agents Environment*. The Semantic Web: Research and Applications Volume 3053/2004 2004 Lecture Notes in Computer Science
  - Mohammadian M., 2004. Intelligent Agents for Data Mining and Information Retrieval. Idea Group Inc.
  - Zhong, N.; Matsui, Y.; Okuno, T. and Liu, C.: *Framework of a Multi-agent KDD System*. Intelligent Data Engineering and Automated Learning - IDEAL 2002: Third International Conference, Manchester, UK, August 12-14, 2002. Proceedings Volume 2412/2002 2002 Lecture Notes in Computer Science
  - Viktor, H.L.: *Cooperating to learn: knowledge discovery through intelligent learning agents MultiAgent Systems*. 2000. Proceedings. Fourth International Conference on 10-12 July 2000 Page(s):453 - 454 2000
  - Stahl, E.: *Employing intelligent agents for knowledge discovery*. Data Engineering, 1998. Proceedings., 14th International Conference on 23-27 Feb. 1998

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## □ Data mining driven agents

- Longbing Cao, Chao Luo, Chengqi Zhang. Developing actionable trading strategies for trading agents, IAT'2007.
- Symeonidis A. and Mitkas, P.: *Agent Intelligence Through Data Mining*. Multiagent Systems, Artificial Societies, and Simulated Organizations Volume 14 2005 2005 Springer US
- Mitkas P. A., D. Kehagias, A.L. Symeonidis, & I. Athanasiadis, 2003. A Framework for Constructing Multi-Agent Applications and Training Intelligent Agents", in Proceedings of the 4th International Workshop on Agent-Oriented Software Engineering (AOSE-2003), Springer-Verlag, Melbourne, Australia, pp. 1-16.
- Symeonidis A.L., P. A. Mitkas, & D. Kehagias, 2002. "Mining patterns and rules for improving agent intelligence through an integrated multi-agent platform", in 6th IASTED International Conference, Artificial Intelligence and Soft Computing, Banff, Alberta, Canada.

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## □ Agent-based distributed mining

- V.Gorodetsky, O.Karsayv, V.Samolov. *Infrastructural Issues for Agent-Based Distributed Learning*. International Workshop "Integration of Agents and Data Mining (IADMI-2006)", Hong Kong, December 18-22, 2006. IEEE Computer Press, 3-6. (Invited talk)
- V.Gorodetsky. *Infrastructural Issues for Agent-Based Distributed Learning* (keynote talk at International Workshop on Interaction between Agents and Data Mining).
- Silva, J. C.; Giannella, C.; Bhargava, R.; Kargupta, H. and Klusch, M. *Distributed data mining and agents*, Engineering Applications of Artificial Intelligence Volume 18, Issue 7, October 2005, Pages 791-807 2005
- Baik, S.W.; Bala, J. and Ju Sang Cho. *Agent-Based Distributed Data Mining*. Parallel and Distributed Computing: Applications and Technologies Volume 3520/2004 2004 Lecture Notes in Computer Science
- Gianelli, C.; Bhargava, R. and Kargupta, H.: *Multi-agent Systems and Distributed Data Mining*. Cooperative Information Agents VIII Volume 3191/2004 2004 Lecture Notes in Computer Science
- Gorodetsky, V.; Karsayev, O. and Samolov, V.: *Multi-agent technology for distributed data mining and classification*. *Intelligent Agent Technology*, 2003. IAT 2003. IEEE/WIC International Conference on 13-16 Oct. 2003 Page(s):438 - 441
- Gorodetsky, V.; Karsayev, O. and Samolov, V.: *Software tool for agent-based distributed data mining*. *Integration of Knowledge Intensive Multi-Agent Systems*, 2003. International Conference on 30 Sept.-4 Oct. 2003 Page(s):710 - 715 2003
- Klusch, M.; Lodi, S. and Moro, G.: *Posters: Issues of agent-based distributed data mining*. Proceedings of the 2003 ACM Conference on Artificial Intelligence, 2003. IAT 2003.
- Klusch, M.; Lodi, S. and Gianluca, M.: *The role of agents in distributed data mining: issues and benefits*. *Intelligent Agent Technology*, 2003. IAT 2003.
- Kargupta H., J. Hamzaoglu, & B. Stafford, 1996. "PADMA: Parallel Data Mining Agents for scalable text classification" in the Proceedings of High Performance Computing.

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- Agent-based peer-to-peer mining
  - V. Gorodetskiy, O. Karsaev, V. Samoilov, S. Serebryakov. Multi-Agent Peer-to-Peer Intrusion Detection. MMM-ACNS-2007. In series "Communication in Computer And Information Systems", volume 1, Springer 2007, pp. 260-271.
  - V. Gorodetskiy, O. Karsaev, V. Samoilov, S. Serebryakov. Agent-based Service-Oriented Intelligent P2P Networks for Distributed Classification. International Conference "Hybrid Information Technologies" (ICHIT-2006), Korea, November 2006, IEEE Computer Press, 224-233.
- Mutual issues
  - Longbing Cao, Chao Luo, Chengqi Zhang. Agent-Mining Interaction: An Emerging Area, AIS-ADM07, LNAI 4476, 60-73, Springer, 2007.
  - V. Gorodetskiy and V. Samoilov. Ontology Issue in Multi-Agent Distributed Learning. In V. Gorodetskiy, J. Liu, V. Skormin (Eds.), "Autonomous Intelligent Systems: Agents and Data Mining", Lecture Notes in Artificial Intelligence", vol. 3505, Springer, 2005, pp. 215-230.

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# Thank you!

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AMII: [www.agentmining.org](http://www.agentmining.org)

F-Trade: [www.f-trade.info](http://www.f-trade.info), [www.ftrade.info](http://www.ftrade.info)

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## AMII Website

- Agent-Mining Interaction & Integration

<http://www.agentmining.org>

- Area evolution
- Research topics
- Research groups
- Publications
- Professional activities
- Projects

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