Modeling Software Agents
in Environmental Management Applications

Dr. Ioannis N. Athanasiadis
ioannis@idsia.ch
www.athanasiadis.info

Dalle Molle Institute for Artificial Intelligence
(Lugano, Switzerland)
Lugano
IDSIA

1986 Referendum for the Centro universitario della Svizzera italiana

1988 IDSIA as a private institute
Supported by Confederation, Canton Ticino and City of Lugano

1996 Università della Svizzera italiana (USI)
Communication Sciences, Economics, Architecture

1997 Scuola universitaria professionale della Svizzera italiana (SUPSI)
Department of computer sciences, …

2000 IDSIA as a joint USI-SUPSI institute

Today: 6 S.R. + 11PD.R + 9 PhD.St + 6 Clrs
a bridge between...

Base research

funded by SNF

machine learning, artificial neural networks, optimization, classifiers

Applied research

funded by CTI, EU, private

vehicle fleet optimization, scheduling, simulation, data mining

The "X-Lab Survey" by Business Week Magazine ranks IDSIA among the world's top ten labs in Artificial Intelligence.
Outline

- Introduction
  - Environmental informatics
  - Software agents
- Software agents in environmental informatics
  - An integrated framework
    - A toolbox of generic agent types
    - A best practice guide
- Applications
  - AMEIM - O₃RTAA – Abacus
  - DAWN
- Conclusions
- Few things on the Seamless project
Environmental informatics

Concepts, definitions and challenges
Working definition

- Enviromatics is an integral part of applied informatics.
  - It provides methodological support for computer application in environmental protection

- Similar terms – initiatives:
  - Ecological informatics
  - Computer-based Integrated Environmental Assessment

Page and Hilty (1994)
Environmental informatics

- Databases
- Usability
- Communications
- Software Engineering
- Hardware

Information Technology
- Neural Networks
- EC GA
- Fuzzy Logic
- Bayesian Techniques

Requirements for environmental problems

Environmental Informatics

Soil Water Air
Landscape Radiation
Noise Waste

Environmental Sciences
- Management Economy
- Administration Law
- Engineering Ecology

Problem solving

Page and Hilty (1994)
Environmental Information Systems

- are concerned
  with the management of data about the soil, the water, the air, and the species in the world around us

- cover a broad range of applications
  including monitoring and control, information management, data analysis, and planning and decision support

• Guenter 1998
• Hilty 2000
Environment itself is an interdisciplinary field
- Value conflicts among the parties formulating the problem
- Different priorities and competences among the final users
- Decision making under uncertainty
  - Data, structure, model

- A peculiar (hostile?) area of applied informatics
- EIS are viewed as being somewhat mysterious and arcane

- Lack of confidence against EIS
Challenges ahead

- Environmental informatics continue to require support
  - The advances in ICT are not uniformly available in the environmental domain
- The so called "Environmental Information vacuum"
  - Two sides, same coin:
    - Data overflow in "developed" countries, information gap in "developing" ones
  - Information availability and quality
    - Data is somehow "raw" and variable in its standards
  - Noisy, incomplete data,
    - "hidden" in legacy systems, reports and other non-reusable forms
- Advances in ICT sector need to be introduced in Enviromatics for solving problems
  - Adapting new techniques such as data mining, probabilistic reasoning systems, artificial neural networks (ANN), and other emerging computing artifacts is required

  - Swayne 2003
Software agents

A novel paradigm for software engineering
Agent technology

Agent-based computing (ABC) is likely to be the next significant breakthrough in software development.

• (Sargent, 1992)
Software agents

- are computational entities that:
  - act on behalf of other entities in an autonomous fashion
  - performs its actions with some level of proactivity and/or reactivity
  - exhibits some level of the key attributes of learning, co-operation and mobility

- Have human-like characteristics
  - Implement behaviors
  - Communicate via messages
  - Have abilities for rational reasoning

- Green 1997

Ioannis Athanasiadis, Cottbus, Germany, 15-21.2.2006
Typical agent

Agent

see

action

Sensor Input

Environment

Action Output

Wooldridge 2000
Agent Oriented Software Engineering

- Design metaphor
  - Open, modular, complex, adaptive, ill-defined systems
  - A natural way to define high level abstractions
  - A way to consider complex systems with multiple distinct and independent components

- Agent technology is part of the software development methods evolution
  - objects → active objects → threads → agents

- Agent-based systems
  - Assistant agents
  - Multi-agent decision systems
  - Multi-agent simulation systems

- Industrial, Academic and Commercial Applications
AOSE: Tools and techniques

- Requirements engineering
  - iStar, Tropos
- Design and modelling
  - GAIA, SODA, EXPAND, AORML
- Formal specification and validation
  - BDI, LORA
- Agent system development languages
  - Programming languages
    - ConGolog, 3APL
  - Communication and coordination languages
    - KQML, FIPA-ACL, KIF
  - Ontology specification languages
    - SHOE, OIL, DAML
  - Ontology development tools
    - Ontolingua, JOE, Protégé-2000
- Agent development platforms
  - JADE, ZEUS, JATLite, JACK
AOSE: Tools and techniques

- There is not a formal framework for agent-based computing
  - The conventional software engineering techniques are not suitable for agent-based computing
    - Maes 1990
  - MAS development depends on the application domains
    - AgentLink 2002
Software agents in environmental informatics

An integrated framework
Agent-Based Computing (ABC)

- Agent research community has developed a plethora of methodologies for
  - Agent-oriented software design
  - Software agent development platforms

ABC in environmental applications?

“Software agents are best suited for applications that are modular, decentralized, changeable, ill-structured, and complex.”

(Parunak 2000)
ABC and EI

● Software agents
  ○ suitable for modular, distributed, evolving, ill-illustrated, complex applications
    (Parunak 2000)

● EI System often have this characteristics
  ○ Multiple levels of abstraction / aggregation
  ○ Data integration with spatiotemporal reference
  ○ Uncertainty problems (structure-data-models)
  ○ Domain complexity
Overall goal

Agent Technology

Environmental Informatics

Problem solving

Requirements for environmental problems

Environmental Sciences
A bibliographic survey of ABC in environmental software applications

In total 23 applications reviewed:

- Grouped in three categories
  - Environmental data management systems
  - Environmental decision support systems
  - Environmental simulation systems

Introspected for the “penetration” of ABC in their software development process
The viewpoint

Software design
- Use some agent-alike modelling “entities”
- Simple agent-models, typically involving UML design
- Agents for software specification
  (e.g. BDI (Rao & Georgeff, 1995), LORA (Wooldridge 2000) or similar techniques.
- Complex agent-oriented software design process
  as Gaia (Zambonelli et al., 2003) and Tropos (Giunchiglia et al.2002).

Software development
- implementation with objects/conventional techniques
- implementation with stand alone software agents
  typically confronting with FIPA standards
- implementation using agent-platforms
  such as JADE, ZEUS, JACK, etc (for a complete list see: Mangina 2002).
The overall picture
Overview

- ABC has been adopted in a limited, rather fragmented way.
- Agent technology is not homogeneously adopted in environmental software developments.
  - The only application reporting an agent-oriented software engineering technique throughout the whole design process is PICO.
- ABC technology hasn’t been diffused at the greatest extent and there are underexploited tools and techniques, available for future work.

A generic methodology is missing for adopting agent technology in environmental software, which will set the frame of work under the particular needs of environmental informatics.
Field of application

Integrated Environmental Decision Support & Data Management Systems

Integrated Environmental Decision Support & Simulation Systems

EDMS

EDSS

ESS

EIS

Ioannis Athanasiadis, Cottbus, Germany, 15-21.2.2006
The notion of agent in EIS

- Mediating role
  - Provision of advanced services

- Common abstract model
  - Analysis-Design-Development of EIS
  - Human-like characteristics

- Operation environment:
  - Natural environment
  - Environmental data objects
  - Environmental software agents
  - Users
Generic abstract model

agent

env\(s_0, a_0\)

env\(s_y a_1\)

Space

Time

\(s_0\) \(s_1\) \(s_2\)
An agent-based toolbox for environmental informatics

We define three generic-purpose agent types:

- Information Carrier
  - Manage and transform EDO
  - Provide information services

- Decision-maker
  - Comprehend EDO and take decisions
    - Deterministic strategies
    - Data-driven strategies
    - Heuristics

- Societal illustrator
  - Act in cooperation / competition with others
  - Form communities
The Information Carrier model

Agent $a_{IC}$

**see**

$(p_1, p_2, p_3)$

**trans**

$i_0$

**state**

$i_1$

**action**

$s_1, s_2, s_3$

**environment**

$O = \{C_{ED(1)}, C_{ED(2)}, \ldots\}$

see: $S \rightarrow P$

trans: $I \times P^* \rightarrow I$

action: $I \rightarrow A$

$P, S \subseteq O, I \subseteq \wp(O)$, and $A \subseteq O^*$
The decision maker model

Agent $a_{DM}$

see $S \rightarrow P$

next: $I \times P \rightarrow I$

engine: $I^* \rightarrow D$

action: $D \rightarrow A$

$P, S, D \subseteq O, I \subseteq \emptyset(O)$, and $A \subseteq O^*$

$O = \{C_{ED(1)}, C_{ED(2)}, \ldots\}$
The Societal Illustrator model

Agent $a_{SI}$

- see
- $p_1$
- next
- $i_0$
- $i_1$
- action

$S \rightarrow P$

$next: I \times P \rightarrow I$

$O = \{O_{ED(1)}, O_{ED(2)}, \ldots\}$

$environment$

$P, S \subseteq O, I \subseteq O^*, \text{ and } A \subseteq O$
An agent-based EIS

$\text{EnvMAS}_{\text{model}} = \{A_1, A_2, A_3, \ldots, A_n, \ldots, A_N\}$

$A_n \in \{IC \cup DM \cup SI\}, \ n = 1 \ldots N$

$\text{EnvMAS} = \{A_1(1), A_1(2), \ldots A_1(K_1), A_2(1), A_2(2), \ldots A_2(K_2), \ldots, A_n(1), A_n(2), \ldots, A_n(K_n), \ldots, A_N(1), A_N(2), \ldots, A_N(K_N)\}$
Abstract system architecture
Software agents in environmental informatics

AOSE

- Information Carriers
- Decision Makers
- Social Illustrators

- Environmental Data Management Systems
- Integrated Environmental Decision Support and Data Management Systems
- Environmental Decision Support
- Integrated Environmental Decision Support & Simulation Systems
- Environmental Simulation Systems

EIS

International Workshop on Rule Based Modelling and Simulation of Interacting Systems and Agents

Ioannis Athanasiadis, Cottbus, Germany, 15-21.2.2006
Demonstration

Integrated Decision Support and Data Management Systems

- AMEIM (generic platform)
  - $O_3$RTAA
    - Ambient air quality assessment and reporting
      Valencia, Spain
  - ABACUS
    - Meteorological radar data management and decision support
      Larnaka, Cyprus

Integrated Decision Support and Data Management Systems

- DAWN
  - Domestic water-supply chain simulator
    Thessaloniki, Greece
Environmental Decision Support and Data Management

AMEIM
O₃RTAA
ABACUS
Application Background

- Environmental Monitoring and Reporting
  - “Near real-time” decisions are made by human experts,
  - Mathematical/statistical models are used for off-line study and understanding of the phenomena involved

- Purpose of use:
  - Operational (short-term)
  - Administrative (long-term)
The main idea

Agents as Decision-makers

Agents as Information Carriers

Integrated EDSS for Data Management

Real-time Monitoring
Measurement Assessment
Alarm notification
Event Prediction
Data validation
AMEIM Topology
Abstract architecture

Management Cluster
- Network orchestration
- Data fusion

Distribution Cluster
- Information Propagation
- Notification services

Contribution Cluster
- Data Collection and Validation
- Estimation of missing values

Data Streams
Agent-based architecture
Using the toolbox

- $O_{3RTAA}^{model} = \{A_{CA}, A_{DMA}, A_{DA}\}$

- $A(O_{3RTAA}) = \{A_{CA}(1), ..., A_{CA}(K_{CA}),$
  $A_{DMA}(1), ..., A_{DMA}(K_{DMA}),$
  $A_{DA}(1), ..., A_{DA}(K_{DA})\}$

- $A(O_{3RTAA}) = \{A_{CA}(SO_2), A_{CA}(O_3), A_{CA}(NO), A_{CA}(NO_2),$
  $A_{CA}(NO_X), A_{CA}(VEL), A_{CA}(DIR), A_{CA}(TEM), A_{CA}(HR),$
  $A_{DMA}(db), A_{DMA}(al), A_{DA}(db), A_{DA}(email), A_{DA}(web)\}$

- $I(O_{3RTAA}) = \{I(1), I(2), I(3), I(4), I(5), I(6)\}$
  - $I(1) : I(A_{CA}(x) \rightarrow A_{DMA}(db)), \ \forall x = 1, 2, ..., K_{CA}$
  - $I(2) : I(A_{DMA}(db) \rightarrow A_{DA}(db))$
  - $I(3) : I(A_{CA}(O_3) \rightarrow A_{DMA}(al))$
  - $I(4) : I(A_{DMA}(al) \rightarrow A_{DA}(web))$
  - $I(5) : I(A_{DMA}(al) \rightarrow A_{DA}(email))$
  - $I(6) : I(A_{CA}(x) \rightarrow A_{CA}(y)), \ \ x \neq y, \ x, y = 1, ..., K_{CA}$

- $O(O_{3RTAA})$
Software design with GAIA-AORML
Agent specification in AUML
Ontology

Meteorological Station

Alarms
- Formal
- Custom

Measurements

Pollutants
- CO
- SO₂
- O₃
- NO₂
- NO
- NOₓ

Time

Meteorological
- Temperature
- Pressure
- Wind
- Relative Humidity

Station Info
- Speed
- Direction
The AMEIM platform
Developed with JADE
The AMEIM platform
Developed with JADE
The AMEIM platform
Developed with JADE

An Agent-based Middleware for Environmental Information Management (AMEIM) - A Graphic User Interface

Input Sources

Sensor

Contribution layer

Processing layer

Delivering layer

An adaptive intelligent layer for environmental management support

Only for the first six agents in every layer a presentation on the GUI screen!
The AMEIM platform
Developed with JADE
The AMEIM platform
Developed with JADE
The AMEIM platform
Developed with JADE
Two test-case applications

- O₃RTAA
  An agent-based middleware application for assessing ambient air quality
- CEAM+IDI EIKON
  Valencia, Spain

- ABACUS
  An agent-based system for meteorological radar data management and decision support
- Meteorological Service Cyprus
Information flow in $O_3$RTAA

Sensor Network

Contribution

Management

Distribution

End User Applications

{(currentMeasurement
(TimeStamp :date 01/06/2001
 :time 08:30)
(Pollutant :attribute O3)
(Value :current 53)
)

Content:
{(sendMeasurement
 (StationInfo :name A)
 (TimeStamp :date 01/06/2001
 :time 06:30)
(O3 :value 53.00
 :unit ug/m3
 :level low
 :variability increasing)
 (Validation :measurement VALID)
 )

Content:
{(sendAlarm
 (TimePerido :date 01/06/2001
 :time From 03:00)
 :time To 09:00)
 (Alarm :status regular
 :color green)
 ...
 )

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ABACUS system goals
The Decision Making Process

- A “deterministic approach” was followed
- All meteorologist agents incorporate several logical rules that consist of
  - An **assumption antecedent** that relates meta-data parameters (indexes) with certain value ranges.
  - A **time constraint** that defines a time interval within the assumption antecedent should be satisfied.
  - The **corresponding alarm**, which is the consequence (decision) in which will the agent will conclude in case that the assumption is satisfied for the corresponding time constraint.
- For shaping complex rules, the user is enabled to prescribe reflection value ranges that correspond to **cloud types** and use them for defining various assumptions.
- Four indexes are calculated and used for building a rule's assumption:
  - Mean reflection value within the annular sector.
  - Mean reflection value per cloud type within the annular sector.
  - Surface coverage percentage per cloud type within the annular sector.
  - Percentage of cells per cloud type within the annular sector.

- Example:
  - if **percentage of cells** within range 50–60dBz is greater than 60% for 3 succeeding scans then raise a sound alarm
Software design with GAIA-AORML

Role Schema: ProcessDataRole (PDR)
Description:
- (ProcessReflections)
- (AwaitReflections)
- (EstimateValues)
- (SendValues)

Protocols and Activities:
- GetSectors
- AwaitReflections
- ProcessReflections
- EstimateValues
- SendValues

Permissions:
- Reads: Clutter Possitions, pixels, GroundClutter
- Generates: Processing Values, String

Responsibilities:
- Safety: True

Role Schema: RuleControlRole (RCR)
Description:
- (ReadRoleParameters)
- (Compare)
- (MakeDecisions)
- (WaitAndGetValues)

Protocols and Activities:
- WaitAndGetValues
- ReadRoleParameters
- Compare
- MakeDecisions

Permissions:
- Reads: Rule Parameters
- Generates: Decisions

Responsibilities:
- Liveness: MF = (WaitAndGetValues. (CheckRole).InformAbacus)
- CheckRole = ReadRoleParameters. Compare. MakeDecisions. [InformMasterMeteorologistAgent]
- Safety: Current Scan >= Memory of system
ABACUS demonstration

Defining custom rules
ABACUS demonstration

Operator’s GUI for a sunny scan
ABACUS demonstration

Operator’s GUI for a stormy scan
ABACUS demonstration

Visualization tools
**ABACUS demonstration**

![ABACUS Logo](image)

**Περιβάλλον ελέγχο και διαχείρισης του μετεωρολογικού ραντάρ "Κίκκος"**

<table>
<thead>
<tr>
<th>Case</th>
<th>Weather Condition</th>
<th>Wind Direction</th>
<th>Temperature</th>
<th>Cloudiness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Επανάληψη</td>
<td>Ανατολή</td>
<td>9.68</td>
<td>Cloudy</td>
</tr>
<tr>
<td>2</td>
<td>Επανάληψη</td>
<td>Ανατολή</td>
<td>1.05</td>
<td>Rainy</td>
</tr>
<tr>
<td>3</td>
<td>Επανάληψη</td>
<td>Ανατολή</td>
<td>1.05</td>
<td>Cloudy</td>
</tr>
<tr>
<td>4</td>
<td>Επανάληψη</td>
<td>Ανατολή</td>
<td>1.70</td>
<td>Rainy</td>
</tr>
<tr>
<td>5</td>
<td>Επανάληψη</td>
<td>Ανατολή</td>
<td>1.72</td>
<td>Sunny</td>
</tr>
</tbody>
</table>

**Web portal**

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Integrated Decision Support and Simulation Systems

DAWN
Application background

- Pricing environmental resources
  - is a field that reflects an unusual monopoly (oligopoly) market of a natural resource whose value includes both an economical and an environmental dimension.

- An individual’s water consumption isn’t related solely to price
  - it also has connections to his/her environmental awareness and social responsibility.
Methodological approach

- A combined approach:
  - Agents as Social Illustrators
    - social simulation
    - influence diffusion
    - environmental dimension of water value
  - Agents as Decision Makers
    - rational decision making
    - econometric model
    - economic dimension of water value
Problem description

- Social influence
  - Mouth-to-mouth communication
- Indirect diffusion
- Two-step model for social influence
  - Opinion leaders
  - Opinion seekers
  - Katz and Lazarsfeld 1955
Influence diffusion mechanism

CA(1,5) neighborhood

CA(3,3) neighborhood

CA(4,2) neighborhood
Agent reasoning

- Generic econometrical model
  \[ C_{i,t} = f(P,Z) \]
  \[ \ln C_{i,t} = \sum_k e_k \ln(f_k[P_{i+1}]) + \sum_l e_l \ln(f_l[Z_i]) \]

- Social influence diffusion model
  \[ S(i,t) = D_i \sum_{j=1}^{N_i} (sw_{j \rightarrow i}) \]

- Hybrid model
  \[ C_{i,t} = f(P,Z',S) \]
  \[ \ln C_{i,t} = \sum_k e_k \ln(f_k[P_{i+1}]) + \sum_l e_l \ln(f_l[Z'_i]) + \sum_m e_m \ln(f_m[S_{i,t}]) \]
Functional framework

DAWN User
(Scientist, Analyst, Decision-maker)

Data collection → Scenario Design

DAWN
(Software platform)

Scenario Model

System self-configuration → Agent-based Simulation

Agent-based Simulation

Scenario evaluation

Result presentation

Iterative process
DAWN Architecture

Scenario Specs → Simulator Agent → Simulation Results

Meteorologist Agent

Water Supplier Agent

DAWN platform

Society of Water Consumer Agents

DAWN Architecture

Scenario Specs

Simulator Agent

Meteorologist Agent

Water Supplier Agent

Society of Water Consumer Agents

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Using the toolbox

\[ DAWN_{model} = \{ A_{SA}, A_{WSA}, A_{CA}, A_{MOA} \} \]

\[ A(DAWN) = \{ A_{SA}(1), A_{WSA}(1), A_{MOA}(1), A_{CA}(1), \ldots, A_{CA}(K_{CA}) \} \]

\[ I(DAWN) = \{ I(1), I(2), I(3), I(4), I(5), I(6), I(7), I(8), I(9), I(10) \} \]

- \( I(1) : I(A_{SA}(1) \rightarrow A_{WSA}(1)) \)
- \( I(2) : I(A_{WSA}(1) \rightarrow A_{MOA}(1)) \)
- \( I(3) : I(A_{MOA}(1) \rightarrow A_{WSA}(1)) \)
- \( I(4) : I(A_{WSA}(1) \rightarrow A_{CA}(i)) \)
- \( I(5) : I(A_{CA}(i) \rightarrow A_{CA}(j)) \)
- \( I(6) : I(A_{CA}(j) \rightarrow A_{CA}(i)) \)
- \( I(7) : I(A_{CA}(i) \rightarrow A_{WSA}(1)) \)
- \( I(8) : I(A_{WSA}(1) \rightarrow A_{SA}(1)) \)
- \( I(9) : I(A_{SA}(1) \rightarrow A_{CA}(i)) \)
- \( I(10) : I(A_{CA}(i) \rightarrow A_{SA}(1)) \)

where \( i = 1, 2, \ldots, K_{CA} \) and \( j = 1, 2, \ldots, N_i \)

\[ O(DAWN) \]
The DAWN platform
Developed with JADE
Conclusion and discussion
An integrative approach ...
Agents for Decision Support in Enviromatics

A triple view
- Information Carriers
- Decision Makers
- Societal Illustrators

Agent technology is able to meet the requirements for supporting Decision-Making in Environmental Informatics Applications
Benefits

- Easily communicable models
- Explainability
  - the human-alike notion of agent
- Rapid prototyping
  - One common model for analysis, design and deployment
- Software reusability
- Multiple loci of control
- Modular architectures
- Agent ability to deal with:
  - value-conflict problems
  - problem complexity
Summary

- An integrated approach on how to exploit ABC in EI
  - ABC was introduced in the EI toolbox from a generic perspective
- A concise methodology assisting the software engineer to develop EIS with agents
  - SA as a common basic unit for the whole software development process
  - Users can be involved in software design
The role of ontologies in Environmental Modelling

And the Seamless-IP project

www.seamless-ip.org
The Seamless project

System for Environmental and Agricultural Modelling; Linking European Science and Society

Topics related to our developments:
Declarative modeling, ontologies and knowledge bases, model integration, simulation platforms
Farming policy analysis in the EU

Analyse the impact of changes on farming systems

Simulate and analyse propose policy changes

Assess interactions between the EU and the rest of the world
Will 2200 farm households still live there?

How will EU and WTO cotton policy impact on Mali’s agriculture?

Odra river – Pyrzice Region - Poland

A typical landscape in Mali
About seamless

- 30 partners
  (13 European countries + Mali + USA)
- Wide expertise
Model integration looks like...

I need the LeafAreaIndex.

Here it is my LAI.

I can produce AirTempMAX.

Who can calculate Air.Temperature.Max.Daily?

MeanSoilTemperature a daily or an annual average?

What about VAR1?

Capito?

!@#$%^?
An ontology...

- Aims to formulate a conceptual schema
  - exhaustive and rigorous
  - about a domain, or “subject”
    - i.e. the matter of interest to some community
- Is a hierarchical data structure containing:
  - the relevant entities
  - their relationships and rules

Source: www.wikipedia.org/wiki/Ontology
Why Develop an Ontology?

- To share **common understanding** of the structure of information
  - among people
  - among software agents
- To enable **reuse** of domain knowledge
  - to avoid “re-inventing the wheel” each time
  - to introduce standards to allow interoperability
More Reasons

- To make **domain assumptions** explicit
  - clarify our perceptions about the domain
  - act as a “lingua franca”
  - easier to share, revise and review
  - easier to understand and update legacy data

- To **separate** domain knowledge from the operational knowledge
  - Declarative vs imperative approach
Our progress so far

- Developed – combined the “core ontologies”
  - Units – dimensions – model interfaces
- Developed a web-based application for registering biophysical models
  - [http://seamless.idsia.ch](http://seamless.idsia.ch)
- Working on
  - Workflow composition ontologies
  - Econometrical model interfaces
Thanks for your attention

Ioannis N. Athanasiadis

ioannis@athanasiadis.info
ioannis@idsia.ch

www.athanasiadis.info