3. Agent-Oriented Methodologies
Part 3:
Design tips and good practices

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MASD
Use case: Distributed River Basin Management

Process description and regulations

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Use case: Distributed River Basin Management

Distributed nature of the problem

- Idea: to build a MAS to coordinate the operation of the 14 Waste Water Treatment Plants (WWTP) located in the Besos River

Chosen AO Methodology: Prometheus

- The Prometheus methodology covers three phases
  - The system specification focuses on identifying the basic functions of the system, along with inputs (percepts), outputs (actions) and their processing (for example, how percepts are to be handled and any important shared data sources to model the system’s interaction with respect to its changing and dynamic environment)
  - The architectural design phase subsequent to system specification determines which agents the system will contain and how they will interact
  - The detailed design phase describes the internals of each agent and the way in which it will achieve its tasks within the overall system. The focus is on defining capabilities (modules within the agent), internal events, plans and detailed data structures.

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Prometheus
System Specification Phase

- System defined by
  - Stakeholders: actors
  - Goals: goal diagram
  - Scenarios: user case scenarios
  - Functionalities: functionality descriptors

- System interface with environment described in terms of
  - actions,
  - percepts
  - external data

Note: Most of the MAS design showed in the following slides was made by CAROLINA RUBIO, ATIA CORTÉS and FRANCESC TRAVESA.
### 3. Agent-Oriented Methodologies

<table>
<thead>
<tr>
<th>STAKEHOLDER</th>
<th>PERFORMANCE</th>
<th>ENVIRONMENT</th>
<th>PERCEPTS</th>
<th>ACTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sewer System</strong></td>
<td>- Drainage and transport of rainfall water, industrial and household wastewater to the receiving media or to a WWTP &lt;br&gt; - Flood protection</td>
<td>- Sewage transportation &lt;br&gt; - Rain overflows &lt;br&gt; - Pollution episodes</td>
<td>- Detect inflow of rainfall water &lt;br&gt; - Detect inflow of household wastewater</td>
<td>- Temporal storage of rainfall water &lt;br&gt; - Check availability of the WWTPs &lt;br&gt; - Collect and transport wastewater to the primary tanks or to the WWTPs</td>
</tr>
<tr>
<td><strong>WWTP</strong></td>
<td>- Recycle sewage &lt;br&gt; - Treat wastewater to be returned to the river according to the Catalan Sanitation Plan</td>
<td>- Urban wastewater treatment</td>
<td>- Detect quantity of produced sewage &lt;br&gt; - Perceive the chemical/toxic components of the water</td>
<td>- Collect and transport wastewater to other WWTPs &lt;br&gt; - Collect and transport wastewater to the river &lt;br&gt; - Check if water treatment is feasible &lt;br&gt; - Apply water treatment &lt;br&gt; - Exposing water between WWTPs</td>
</tr>
<tr>
<td><strong>Industry</strong></td>
<td>- Obey the Catalan Sanitation Plan &lt;br&gt; - Collect and transport wastewater for its processing</td>
<td>- Pollutant treatments</td>
<td>- Detect quantity of produced sewage</td>
<td>- Collect and transport sewage to the river, TANKER or sewer &lt;br&gt; - Inform about toxic effluent dumped</td>
</tr>
<tr>
<td><strong>River</strong></td>
<td>- Maintenance of an acceptable quantity and quality of the water &lt;br&gt; - Receiving water &lt;br&gt; - Perceive the chemical/toxic components of the water</td>
<td>- Receiving water</td>
<td>- Process quality and quantity data to warn about fraudulent dumps into the river</td>
<td></td>
</tr>
</tbody>
</table>

### System Specification phase

#### Scenarios (1 of 2)

**Scenario 1**: Treat industry’s uncontrolled toxic effluent

**Overview**: An industry has an uncontrolled toxic effluent and warns authorities

**Context**: The toxic concentration in the industrial wastewater is unexpectedly high

**Steps**
1. **(Perceive)** Detect quantity of produced wastewater
2. **(Action)** Collect and transport wastewater to Industrials tanks
3. **(Action)** Inform about toxic effluent dumped
4. **(Action)** Collect and transport wastewater into the TANKER
5. **(Action)** Check availability of the WWTPs
6. **(Action)** Collect and transport wastewater into the suitable WWTP
7. **(Action)** Apply WW treatment

**Variations**: Step 4. Collect and transport WW to the sewer system

**Scenario 2**: Process a non-notified toxic effluent

**Overview**: A wastewater treatment plant detects a non-notified toxic effluent and needs help to process it

**Context**: It is not mandatory for the UWS to have a treatment for the toxic effluent

**Steps**
1. **(Perceive)** Perceive the chemical/toxic components of the water
2. **(Action)** Check if water treatment is feasible
3. **(Action)** Bypassing water between WWTPs
4. **(Action)** Apply WW treatment

**Variations**: Step 3. Apply the primary treatment to the wastewater
System Specification phase
Scenarios (2 of 2)

<table>
<thead>
<tr>
<th>SCENARIO 3</th>
<th>Avoid storm water overflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERVIEW</td>
<td>There is a mild thunderstorm and a waste water treatment plant cannot process all the inflow alone, and needs to coordinate with others</td>
</tr>
<tr>
<td>CONTEXT</td>
<td>The sewer system has only one pipe that collects and transports together the storm water and the different types of wastewater</td>
</tr>
</tbody>
</table>
| STEPS       | 1. (Percept) Detect inflow of rainfall water  
               2. (Action) Collect and transport water to the pluvial tanks  
               3. (Activity) Temporal storage of rainfall water  
               4. (Action) Check availability of the WWTPs  
               5. (Action) Bypassing water between WWTPs  
               6. (Action) Collect and transport water to the river |
| VARIATIONS  | Step 5. Collect and transport water to the river |

Except in extreme situations, the goal diagram...
- should be a fully-connected graph
- The abstraction level should be balanced in the different branches,
- All (sub)goals should be linked to scenarios
System Specification phase
Goal Overview Diagram: improved

3. Agent-Oriented Methodologies

An example of what NOT to do…
(I won’t reveal the authors)
A good practice:
Keep roles/activities small and specific, so later during design phase you have more flexibility to group them into agents

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Prometheus
Architectural Design Phase: Identifying Agent types

- option 1: There exists no definition in the environment → we have to identify them
  - Group functionalities to agent types based on cohesion and coupling
  - Group functionalities that are
    - related based on common sense
    - group functionalities that require a lot of the same information:
      - Data Coupling Diagram
  - Do not group functionalities that are
    - clearly unrelated
    - exist on different hardware platform
    - security and privacy
    - Modifiable by different people
  - Evaluate grouping:
    - Simple descriptive names (heuristic)
    - Generate agent acquaintance diagram

- option 2: The domain already defines the agent types

Identifying agent types
Option 1: The domain does not define stakeholder types/roles

Example from the Prometheus creators (On-line book store)

Stock Manager Agent
Sales Assistant Agent
Delivery Manager Agent

Customer Assistant Agent
Identifying agent types
Option 1: Example of Agent Descriptor for the on-line Book Store

<table>
<thead>
<tr>
<th>Name: Sales Assistant agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: greets customer, follows through site, assists with finding books.</td>
</tr>
<tr>
<td>Cardinality: one customer</td>
</tr>
<tr>
<td>Lifetime: Instantiated on customer arrival at site. Denies when customer logs out or after inactivity period.</td>
</tr>
<tr>
<td>Initialisation: Obtains cookie. Reads Customer DB.</td>
</tr>
<tr>
<td>Source: Copies open DB connections.</td>
</tr>
<tr>
<td>Functionalities included: Online Interaction, Sales Transaction, Welcome, Book Finder.</td>
</tr>
<tr>
<td>Uses data: Customer DB, Customer Orders, Book DB.</td>
</tr>
<tr>
<td>Produces data: Customer preferences, orders, queries</td>
</tr>
<tr>
<td>Goals: Welcome customer; Update customer details; Respond to queries; Facilitate purchases;</td>
</tr>
<tr>
<td>Events responded to: new arrivals, customer query; customer purchase; credit check.</td>
</tr>
<tr>
<td>Actions: Display information to customer (greetings, book info, info requests, Display Customized WWW page, Request/CreditCheck messages.</td>
</tr>
<tr>
<td>Interacts with: Warehouse Manager (book request protocol), Delivery Manager (order protocol), order query protocol, Customer Manager (customer information query protocol), customer information update protocol.</td>
</tr>
</tbody>
</table>

Identifying agent types
Option 2: These are predefined in the domain
Identifying agent types

Option 2: Example of Agent Descriptor for the Besos River scenario

<table>
<thead>
<tr>
<th>AGENT</th>
<th>WWTP AGENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESCRIPTION</td>
<td>Collection of treatment plants where wastewaters are treated chemically for its sanitation and discharged into the river</td>
</tr>
<tr>
<td>CARBONITY</td>
<td>N (as many treated plants as the WWTP considers)</td>
</tr>
<tr>
<td>EMPOWERED</td>
<td>WWTP production, Collection and distribution of water, WW treatment, Bypass management</td>
</tr>
<tr>
<td>SIDE EFFECTS</td>
<td>Influent, WWTP availability, Toxic compounds, Chemical parameters, Physical parameters, Biological/physiological parameters, Treatment model, Macroscopic observation of WWTP</td>
</tr>
<tr>
<td>PRODUCES DATA</td>
<td>Toxic compounds, Chemical parameters, Physical parameters, Biological/physiological parameters, Influential, WWTP availability, Treatment model, COD, BOD, TSS removed</td>
</tr>
<tr>
<td>GOALS</td>
<td>Maintain an acceptable volume of water, Control WWTP's overload, Obey the Catalan Sanitation Plan, Reshuffle grate, Maintain an acceptable quality of water</td>
</tr>
<tr>
<td>EVENTS RESPONSIBLE TO</td>
<td>Select quantity of residual wastewater, Permits the chemical/biochemical components of the water</td>
</tr>
<tr>
<td>ACTIONS</td>
<td>Apply WW treatment, Check if water treatment is feasible, Check availability of WWTPs, Collect and transport water to the WWTPs, Collect and transport water to the river, Bypass water between WWTPs</td>
</tr>
<tr>
<td>INTERACTS WITH</td>
<td>WWTP Agent collects availability and protocols, WWTP re-transport protocols, Industry Agent (industry tanker we transport protocols), Bower System Agent (river we transport protocols)</td>
</tr>
</tbody>
</table>

Prometheus

Architectural Design Phase: System Overview Diagram

Key:
- Agent
- Data
- Message
- Event
- Protocol
Design Tip: When agent communication?

- Any protocol interaction should come from some agent communication needs.
- Goals for Agent Communication:
  - Agents able to request (to other ags.) actions or services that they cannot perform by themselves
  - Agents able to ask for information (to other ags.)
  - Agents able to share their beliefs with other ags.
  - Agents able to coordinate with other ags. To solve complex tasks.

- Design Tip:
  - In Prometheus any protocol interaction should be connected to a (sub)goal.

Prometheus
Architectural Design Phase: Protocol description

<table>
<thead>
<tr>
<th>PROTOCOL</th>
<th>DESCRIPTION</th>
<th>AGENTS INVOLVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewer ww transport</td>
<td>Transports ww from the sewer system to the nearest WWTP</td>
<td>Sewer System -&gt; WWTP</td>
</tr>
<tr>
<td>River discharge warning</td>
<td>Notifies the Authority that the Sewer System discharges ww to the river</td>
<td>Sewer System -&gt; Authority</td>
</tr>
<tr>
<td>WWTP ww transport</td>
<td>Sends ww from a WWTP to another</td>
<td>WWTP -&gt; WWTP</td>
</tr>
<tr>
<td>WWTP availability request</td>
<td>Requests an available WWTP to treat a toxic effluent</td>
<td>WWTP &lt;-&gt; WWTP Industry -&gt; WWTP Sewer System -&gt; WWTP</td>
</tr>
<tr>
<td>Pollutant dumped warning</td>
<td>Industry notifies the discharge of ww</td>
<td>Industry &lt;-&gt; Authority</td>
</tr>
<tr>
<td>Industry tanker ww transport</td>
<td>Non-expected ww stored in the industrial tanker transported into the WWTP</td>
<td>Industry -&gt; WWTP</td>
</tr>
<tr>
<td>Industrial ww transport</td>
<td>ww coming from industry that pass by the Sewer System before going to the WWTP</td>
<td>Industry -&gt; Sewer System</td>
</tr>
</tbody>
</table>
Prometheus
Detailed Design Phase

- The details of the agent internals are developed
  - Defined in terms of capabilities, data, events and plans
  - Process diagrams are used as stepping stone between interaction protocols and plans
- Steps (I)
  - Develop the internal structure of individual agents
  - Identify the capability of each agent (start with functionalities)
  - Generate **capability descriptors**

**Name**: Bypass channel management
**External interface to the capability**: events used/produced
**Natural language description**: Respond if books are not in stock
**Interaction with other capabilities**: Blackwater problem
**Data used/produced by the capability**: Note problem to transport capability
**Inclusion of other capabilities**: None

- Generate **agent overview diagrams**
Prometheus
Detailed Design Phase: Event, Data & Plan Descriptions

- **Steps (II)**
  - **Plan descriptions**
    - **Name**: Activated Sludge Plan
    - **Natural language description**: Process WW with slidges in tank
    - **Triggering event type**: Detected quality of incoming water
    - **Plan steps**: Apply WW treatment
    - **Context of performing the plan**: normal functioning
    - **Data used/produced**: none

- **Event descriptions**
  - Identify the purpose of events and the data carried by it

- **Data descriptions**
  - Identify the data structure and operations on the data

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References


These slides are based mainly in [2], [4], [5] and material from previous students of the MASD course.