Multi-Agent Programming Contest Contest Protocol Description (2008 Edition)

http://cig.in.tu-clausthal.de/agentcontest2008/

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1 Scenario: Cows and Herders

An unknown species of cattle was recently discovered in the unexplored flatlands of Lemuria. The cows have some nice features: their carbondioxyde- and methane-output is extremely low compared to the usual cattle and their beef and milk are of supreme quality and taste.

These facts definitely caught the attention of the beef- and milk-industries. The government decided to allow the cows to be captured and bred by everyone who is interested and has the capabilities. Several well-known companies decided to send in their personnel to the fields to catch as many of them as possible. This led to an unprecedented rush for cows. To maximise their success the companies replaced their traditional cowboys by *artificial herders*.

In this year's agent contest the participants have to compete in an environment for cows. Each team controls a set of herders in order to direct the cows into their own corral. The team with the most cows in the corral at the end wins the match.

2 General Agent-2-Server Communication Principles

In this contest, the agents from each participating team will be executed locally (on the participant's hardware) while the simulated environment, in which all agents from competing teams perform actions, is run on the remote contest simulation server.

Agents communicate with the contest server using standard TCP/IP stack with socket session interface. The Internet coordinates (IP address and port) of

the contest server (and a dedicated test server) will be announced later via the official Contest mailing list.

Agents communicate with the server by exchanging XML messages. Messages are well-formed XML documents, described later in this document. We recommend using standard XML parsers available for many programming languages for generation and processing of these XML messages.

3 Communication Protocol

Logically, the tournament consists of a number of matches. A match is a sequel of simulations during which two teams of agents compete in several different settings of the environment. However, from agent's point of view, *the tournament consists of a number of simulations in different environment settings and against different opponents.*

The tournament is divided into three phases. During the initial phase, agents connect to the simulation server and identify themselves by username and password (`AUTH-REQUEST` message). Credentials for each agent will be distributed in advance via e-mail. As a response, agents receive the result of their authentication request (`AUTH-RESPONSE` message) which can either succeed, or fail. After successful authentication, agents should wait until the first simulation of the tournament starts.

At the beginning of each simulation, agents of the two participating teams are notified (`SIM-START` message) and receive simulation specific information:

- simulation ID,
- opponent's ID,
- grid size,
- corral position and size, and
- number of steps the simulation will last.

In each simulation step each agent receives a perception about its environment (`REQUEST-ACTION` message) and should respond by performing an action (`ACTION` message). Each `REQUEST-ACTION` message contains

- information about the cells in the visibility range of the agent (including the one agent stands on),
- the agent's absolute position in the grid,
- the current simulation step number,
- the number of caught cows and
- the deadline for responding.

The agent has to deliver its response within the given deadline. The action message has to contain the identifier of the action, the agent wants to perform, and action parameters, if required.

When the simulation is finished, participating agents receive a notification about its end (`SIM-END` message) which includes

- the information about the number of caught cows, and
- the information about the result of the simulation (whether the team has won or lost the simulation).

All agents which currently do not participate in a simulation should wait until the simulation server notifies them about either 1) the start of a simulation, they are going to participate in, or 2) the end of the tournament.

At the end of the tournament, all agents receive a notification (`BYE` message). Subsequently the simulation server will terminate the connections to the agents.

3.1 Reconnection

When an agent loses connection to the simulation server, the tournament proceeds without disruption, only all the actions of the disconnected agent are considered to be empty (*skip*). Agents are themselves responsible for maintaining the connection to the simulation server and in a case of connection disruption, they are allowed to reconnect.

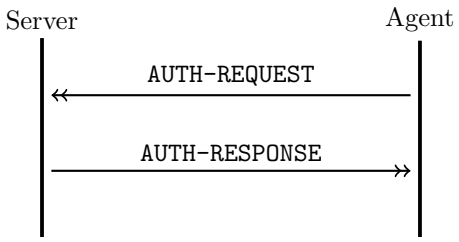
Agent reconnects by performing the same sequence of steps as at the beginning of the tournament. After establishing the connection to the simulation server, it sends `AUTH-REQUEST` message and receives `AUTH-RESPONSE`. After successful authentication, server sends `SIM-START` message to an agent. If an agent participates in a currently running simulation, the `SIM-START` message will be delivered immediately after `AUTH-RESPONSE`. Otherwise an agent will wait until a next simulation in which it participates starts. In the next subsequent step when the agent is picked to perform an action, it receives the standard `REQUEST-ACTION` message containing the perception of the agent at the current simulation step and simulation proceeds in a normal mode.

3.2 Ping Interface

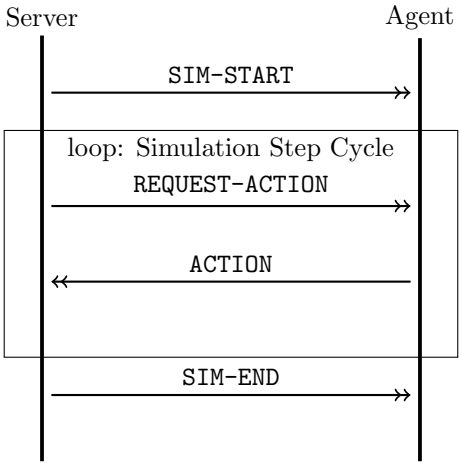
The simulation server provides a ping interface in order to allow agents to test their connection to the simulation server. Agent can send a `PING` message containing a payload data (ASCII string up to 100 characters) and it will receive `PONG` message with the same payload. As all messages contain a timestamp (see description of the message envelope below), agent can also use ping interface to synchronize its time with the server.

3.3 Protocol Sequence Diagram (UML like notation)

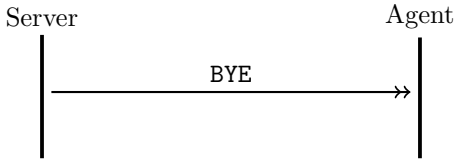
- Initial phase



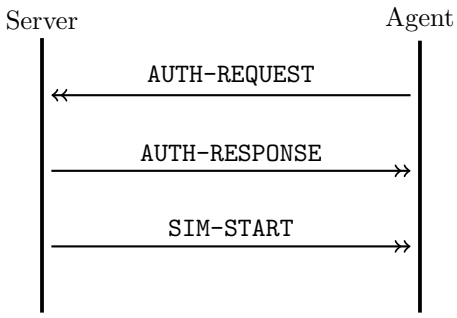
- Simulation



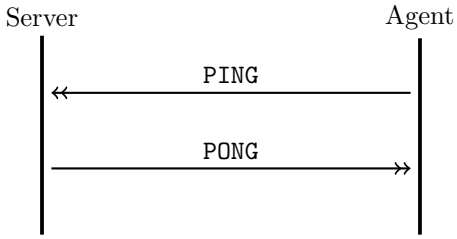
- Final phase



- Reconnect



- Ping



3.4 XML Messages Description

3.4.1 XML message structure

XML messages exchanged between server and agents are zero terminated UTF-8 strings. Each XML message exchanged between the simulation server and agent consists of three parts:

- Standard XML header: Contains the standard XML document header

  ```
  <?xml version="1.0" encoding="UTF-8"?>
  ```

- Message envelope: The root element of all XML messages is `<message>`. It has attributes the timestamp and a message type identifier.

- Message separator: Note that because each message is a UTF-8 zero terminated string, messages are separated by nullbyte.

The timestamp is a numeric string containing the status of the simulation server's global timer at the time of message creation. The unit of the global timer is milliseconds and it is the result of standard system call "time" on the simulation server (measuring number of milliseconds from January 1st, 1970 UTC). Message type identifier is one of the following values: `auth-request`,

`auth-response`, `sim-start`, `sim-end`, `bye`, `request-action`, `action`, `ping`, `pong`.

Messages sent from the server to an agent contain all attributes of the root element. However, the timestamp attribute can be omitted in messages sent from an agent to the server. In the case it is included, server silently ignores it.

Example of a server-2-agent message:

```
<message timestamp="1138900997331" type="request-action">
  <!-- optional data -->
</message>
```

Example of an agent-2-server message:

```
<message type="auth-request">
  <!-- optional data -->
</message>
```

Optional simulation specific data According to the message type, the root element `<message>` can contain simulation specific data.

3.4.2 `AUTH-REQUEST` (agent-2-server)

When the agent connects to the server, it has to authenticate itself using the username and password provided by the contest organizers in advance. This way we prevent the unauthorized use of connection belonging to a contest participant. `AUTH-REQUEST` is the very first message an agent sends to the contest server.

The message envelope contains one element `<authentication>` without subelements. It has two attributes `username` and `password` of type string.

Example:

```
<?xml version="1.0" encoding="UTF-8"?>
<message type="auth-request">
  <authentication username="xteam5" password="jabjar5"/>
</message>
```

3.4.3 `AUTH-RESPONSE` (server-2-agent)

Upon receiving `AUTH-REQUEST` message, the server verifies the provided credentials and responds by a message `AUTH-RESPONSE` indicating success, or failure of authentication. It has one attribute `timestamp` that represents the time when the message was sent.

The envelope contains one `<authentication>` element without subelements. It has one attribute `result` of type string and its value can be either `"ok"`, or `"fail"`. Example:

```
<?xml version="1.0" encoding="UTF-8"?>
<message timestamp="1204979083919" type="auth-response">
  <authentication result="ok"/>
</message>
```

3.4.4 `SIM-START` (server-2-agent)

At the beginning of each simulation the server picks two teams of agents to participate in the simulation. The simulation starts by notifying the corresponding agents about the details of the starting simulation. This notification is done by sending the `SIM-START` message.

The data about the starting simulation are contained in one `<simulation>` element with the following attributes:

- `id` - unique identifier of the simulation (string),
- `opponent` - unique identifier of the enemy team (string),
- `steps` - number of steps the simulation will perform (numeric),
- `gsizex` - horizontal size of the grid environment (west-east) (numeric),
- `gsizey` - vertical size of the environment (north-south) (numeric),
- `corralx0` - left border of the corral (numeric),
- `corralx1` - right border of the corral (numeric),
- `corraly0` - upper border of the corral (numeric),
- `corraly1` - lower border of the corral (numeric).

Remark: One step involves all agents acting at once. Therefore if a simulation has n steps, it means that each agent will receive `REQUEST-ACTION` messages exactly n times during the simulation (unless it loses the connection to the simulation server).

Example:

```
<?xml version="1.0" encoding="UTF-8"?>
<message timestamp="1204979126544" type="sim-start">
  <simulation
    corralx0="0"
    corralx1="14"
    corraly0="55"
    corraly1="69"
    gsizex="70" gsizey="70"
    id="stampede"
    opponent="xteam"
    steps="10"/>
</message>
```

3.4.5 SIM-END (server-2-agent)

Each simulation lasts a certain number of steps. At the end of each simulation the server notifies agents about its end and its result.

The message envelope contains one element `<sim-result>` with two attributes `score` and `result`. `score` attribute contains number of caught in the corral of the team the given agent belongs to, and `result` is a string value equal to one of `"win"`,`"lose"`,`"draw"`. The element `<sim-result>` does not contain subelements.

Example:

```
<?xml version="1.0" encoding="UTF-8"?>
<message timestamp="1204978760356" type="sim-end">
  <sim-result result="draw" score="9"/>
</message>
```

3.4.6 BYE (server-2-agent)

At the end of the tournament the server notifies each agent that the last simulation has finished and subsequently terminates the connections. There is no data within the message envelope of this message.

Example:

```
<?xml version="1.0" encoding="UTF-8"?>
<message timestamp="1204978760555" type="bye"/>
```

3.4.7 REQUEST-ACTION (server-2-agent)

In each simulation step the server asks the agents to perform an action and sends them the corresponding perceptions.

The message envelope of the `REQUEST-ACTION` message contains the element `<perception>` with six attributes:

- `step` - current simulation step (numeric),
- `posx` - column of current agent's position (numeric),
- `posy` - row of current agent's position (numeric),
- `score` - number of cows caught in the corral of the agent's team until the current simulation step (numeric),
- `deadline` - server global timer value until which the agent has to deliver a reaction in form of an `ACTION` message (the same format as timestamp),
- `id` - unique identifier of the `REQUEST-ACTION` message (string).

The element `<perception>` contains a number of subelements `<cell>` with two numeric attributes `x` and `y` that denote the cell's relative position to the agent.

If an agent stands near the grid border, or corner, only the perceptions for the existing cells are provided.

Each element `<cell>` contains a number of subelements indicating the content of the given cell. Each subelement is an empty element tag without further subelements:

- `<agent>` - there is an agent in the cell. The string attribute `type` indicates whether it is an agent of the enemy team, or ally. Allowed values for the attribute `type` are `"ally"` and `"enemy"`.
- `<obstacle>` - the cell contains an obstacle. This element has no associated attributes.
- `<cow>` - the cell contains a cow. The string attribute `ID` represents the cow's unique identifier.
- `<corral>` - the cell is a corral cell. The string attribute `type` indicates whether it belongs to the team's or the opponent's corral. Allowed values for the attribute `type` are `"ally"` and `"enemy"`.
- `<empty>` - the cell is empty.
- `<unknown>` - the content of a cell is not provided by the server because of information distortion.

The specific rules on allowed combinations of objects in a cell are provided in the scenario description.

Example (compare to Fig. 1):

```
<?xml version="1.0" encoding="UTF-8"?>
<message timestamp="1205147104629" type="request-action">
  <perception
    step="0"
    posx="13"
    posy="35"
    score="0"
    deadline="1205147112629"
    id="1">
    <cell x="-8" y="-8"><empty/></cell>
    ...
    <cell x="-8" y="0"><agent Type="ally"/></cell>
    ...
    <cell x="-8" y="5"><corral type="ally"/></cell>
    <cell x="-8" y="6"><corral type="ally"/></cell>
    <cell x="-8" y="7"><corral type="ally"/></cell>
    <cell x="-8" y="8"><corral type="ally"/></cell>
    ...
    <cell x="-7" y="5"><corral type="ally"/></cell>
```

```
    <cell x="-7" y="6"><corral type="ally"/></cell>
    <cell x="-7" y="7"><corral type="ally"/></cell>
    <cell x="-7" y="8"><corral type="ally"/></cell>
    ...
    <cell x="-6" y="0"><agent type="ally"/></cell>
    ...
    <cell x="-6" y="5"><corral type="ally"/></cell>
    <cell x="-6" y="6"><corral type="ally"/></cell>
    <cell x="-6" y="7"><corral type="ally"/></cell>
    <cell x="-6" y="8"><corral type="ally"/></cell>
    ...
    <cell x="-5" y="2"><cow ID="47"/></cell>
    <cell x="-5" y="3"><unknown/></cell>
    <cell x="-5" y="4"><cow ID="52"/></cell>
    <cell x="-5" y="5"><corral type="ally"/></cell>
    <cell x="-5" y="6"><corral type="ally"/></cell>
    <cell x="-5" y="7"><corral type="ally"/></cell>
    <cell x="-5" y="8"><corral type="ally"/></cell>
    ...
  </perception>
</message>
```

Note that the agent perceives an area that is a square with the size 17 with the agent in the center. Thus each agent is able to see 289 cells. We refrained from depicting all 289 cells in the above example and showed just some of the relevant cells instead. The three dots indicate the missing `<cell>` elements.

3.4.8 `ACTION` (agent-2-server)

The agent should respond to the `REQUEST-ACTION` message by an action it chooses to perform.

The envelope of the `ACTION` message contains one element `<action>` with the attributes `type` and `id`. The attribute `type` indicates an action the agent wants to perform. It contains a string value which can be one of the following strings:

- `"skip"` – (the agent does nothing),
- `"north"` – (the agent moves one cell to the top) ,
- `"northeast"` – (the agent moves one cell to the top and one cell to the right),
- `"east"` – (the agent moves one cell to the right),
- `"southeast"` – (the agent moves one cell to the right and one cell to the bottom),
- `"south"` – (the agent moves one cell to the bottom),

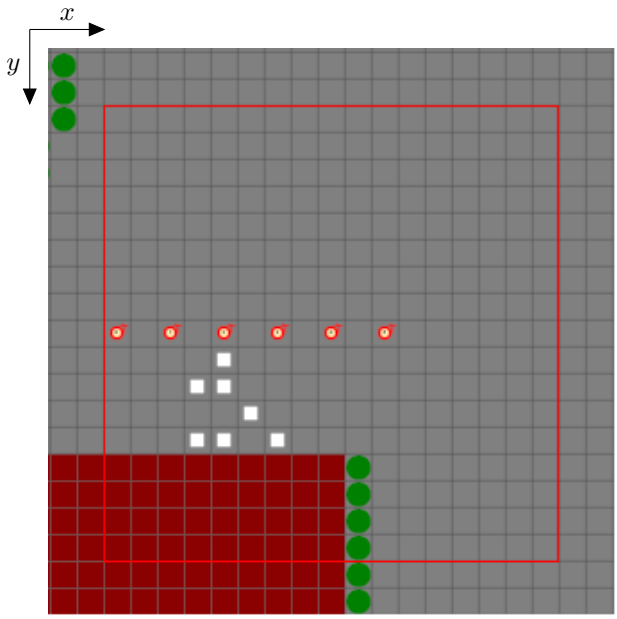


Figure 1: The view range of the agents. The agent is in the center and perceives all the cells in the red rectangle. Cows are white squares, trees are green circles.

- `"southwest"` – (the agent moves one cell to the bottom and one to the left),
- `"west"` – (the agent moves one cell to the left),
- `"northwest"` – (the agent moves one cell to the left and one to the top).

The attribute `id` is a string which should contain the `REQUEST-ACTION` message identifier. The agents must plainly copy the value of `id` attribute in `REQUEST-ACTION` message to the `id` attribute of `ACTION` message, otherwise the action message will be discarded.

Note that the corresponding `ACTION` message has to be delivered to the time indicated by the value of attribute `deadline` of the `REQUEST-ACTION` message. Agents should therefore send the `ACTION` message in advance before the indicated deadline is reached so that the server will receive it in time.

Example:

```
<?xml version="1.0" encoding="UTF-8"?>
<message type="action">
  <action id="70" type="skip"/>
</message>
```

3.4.9 PING (agent-2-server)

In order to allow agents to test the speed of their internet connection the simulation server provides a ping interface. The agent is allowed to send PING messages to the server.

The message envelope of this message contains the element <payload> with one attribute value. value contains an arbitrary string up to 100 characters long. The payload value is plainly copied to the payload value of the corrensponding PONG message by the server. The agents can use it to store proprietary data in the case they need it.

Note that if the server receives a PING message with a payload longer than 100 characters, it can discard the PING message and will not respond to it.

Example:

```
<?xml version="1.0" encoding="UTF-8"?>
<message type="ping">
  <payload value="hello World"/>
</message>
```

3.4.10 PONG (server-2-agent)

When the simulation server receives a PING message it immediately responds by sending a PONG message.

The envelope contains one element <payload> with a string attribute value. Its value is copied from the corresponding PING message.

Example:

```
<?xml version="1.0" encoding="UTF-8"?>
<message timestamp="1204978759491" type="pong">
  <payload value="hello World"/>
</message>
```

4 Remarks and notes

4.1 Ill-formed messages

Not well-formed XML messages received by the server from agents are discarded. This means, that if some obligatory information (element, or attribute) of a given message is missing the server silently ignores it. In the case that a message will contain additional not-required informations, only the first occurence is processed by the server. We strongly recommend to comply with the communicatison protocol described above.

Examples:

```
<?xml version="1.0" encoding="UTF-8"?>
<message type="auth-request">
  <authentication username="team1agent1" password="qwErTY"/>
```

```
  <authentication username="team1agent32" password="11111WWw"/>
  <some-element arbitrary="234TreE"/>
</message>
<message type="action">
  <authentication username="team1agent1" password="qwErTY"/>
  <authentication username="team1agent1" password="qwErTY"/>
  <some-element arbitrary="234TreE"/>
</message>
```

The message above will be processed as an `AUTH-REQUEST` message with the credentials `team1agent1/qwErTY`.

```
<?xml version="1.0" encoding="UTF-8"?>
<message type="ping">
  <payload value="payload1"/>
  <payload value="payload2"/>
</message>
```

This message will be processed as a regular `PING` message and the `PONG` response will include a payload equal to `payload1`.

4.2 Pinging and flooding (DoS attack attempts)

Although we do not impose any upper limits on the frequency of pinging, we strongly discourage abuse of pinging interface by either flooding the simulation server by `PING` messages, or other malformed messages with large payload. All suspicious cases will be considered as a DoS attack attempt and will be dealt with by organizers. This can possibly lead to team disqualification.

5 Further Important Informations

5.1 Weights

The weights for the cow-algorithm are as follows:

- $w(cow) \in [1, 10]$ - attraction by cows that are visible and not in the private-range
- $w(cow_{private}) \in [-1, -10]$ - repulsion by cows that are visible and in the private-range
- $w(agent) \in [-100, -300]$ - repulsion by agents that are visible
- $w(empty) \in [1, 10]$ - attraction by empty cells
- $w(tree) := -w(empty)$ - repulsion by trees
- $w(corral) := w(empty)$ - attraction by corral cells

5.2 Visibility Ranges

The visibility ranges are as follows:

- cows have a visibility square that is 9 cells in width and in height, the cow is considered to be in the center,
- cows have a private square that is 3 cells in width and in height, the cow is considered to be in the center, and
- agents have a visibility square that is 17 cells in width and in height, the agent is considered to be in the center.

Please refer to the Fig. 1 and Fig. 2 and for an illustration of the ranges.

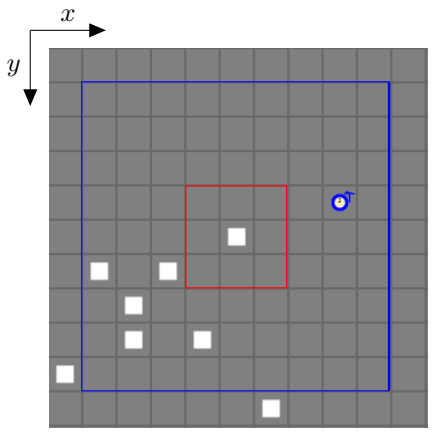


Figure 2: The view range of the cows. The cow is in the center and perceives all the cells in the blue rectangle. Cells in the red rectangle are in the private range.

5.3 Probabilities

The probability that the content of a cell is not perceived by the agent is around 10%. The probability that an agent's action fails is around 10%.

5.4 Points

Each cow that enters a corral-cell gives the team that belongs to the corral one point for the simulation. The cow then disappears. The agent teams that wins by collecting more cows gets 3 points for the overall tournament, the loosing team gets 0 points. In the case of a draw, i.e. both agents have collected the same amount of cows, both teams get 1 point for the tournament.