D8.2.1 Report: *mWater* Analysis and Design

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Abstract.
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The mWater demonstrator problem description is detailed in this report.
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Executive Summary

Water scarcity is becoming a major concern in most countries, not only because it threatens the economic viability of current agricultural practices, but because it is likely to alter an already precarious balance among its many types of use: human consumption, industrial use, energy production, recreation, etc. Underneath this emergent situation, the crude realities of conflict over water rights of use and the need of accurate assessment of water needs and use become more salient than ever.

In countries like Spain, and particularly in its Mediterranean coast, there is a high degree of public awareness of the main consequences of the scarcity of water and the need of fostering efficient use of water resources. Two new mechanisms for water management already under way are: a heated debate on the need and feasibility of transferring water from one basin to another, and, directly related to this proposal, the regulation of *water banks*.[1]

It has been sufficiently argued that more efficient uses of water may be achieved within an institutional framework where water rights may be exchanged more freely, not only under exceptional conditions but on a day to day basis [Cal06, RGL04, Tho97]. It has been claimed that if farmers cannot sell their extra water allotment, they have no incentive to use the allotment efficiently and it may become wasteful [HR07]. Moreover, a straightforward extension to other types of stakeholders would promote trading for industrial uses, aquiculture, leisure or navigation, not only irrigation, thus improving market conditions and hence efficiency of water use [Cal06]. We propose to implement such a market with a regulated open multi-agent system, *mWater*, whose main features we discuss in this paper.

Our focus is on demand and, in particular, on the type of regulatory and market mechanisms that foster an efficient use of water while preventing conflicts.[2] We are therefore

[1] The 2001 Water Law of the National Hidrological Plan (NHP) —'Real Decreto Legislativo 1/2001, BOE 176' (see www.boe.es/boe/dias/2001/07/24/pdfs/A26791-26817.pdf, in Spanish)— and its amendment in 2005 regulates the power of right-holders to engage in voluntary water transfers, and of basin authorities to setup water markets, banks, and trading centers for the exchange of water rights in cases of drought or other severe scarcity problems.

[2] Considerable effort has been invested in the development of sophisticated basin simulation models and in improvement and innovation of water use practices. Literature abounds in examples of decision support systems for water management [RN05], sustainable planning of water volumes [CLM04, MdSODO$^+$07], or the use of shared visions for negotiation and conflict resolution [PWMW99]. We explore an alternative approach in which individual and collective agents are an essential component because their behavior (and effects) may be influenced by policy-making. There are few projects along this line but one may point to the NEGOWAT project (http://www.negowat.org/ingles/inicio/Inicio.htm), whose goal is to help

interested in the institutional framework that defines the "rules of the game" that may allow one to study the role that regulation, social environment, coordination, conflict resolution mechanisms, reputation or trust play in the decisions participating agents make and their aggregate results. Ideally, the institutional framework should add flexibility to current water use practices without increasing the number or complexity of disputes. In such a framework we shall profit from agreement technologies to understand the behaviour of participating agents and the collective effects of their behavior.

The following is a sketch of four study themes that, we believe, make the *mWater* framework a fertile case-study for the testing and development of agreement technologies.

A regulated environment The *mWater* scenario requires the expression and use of regulations of different sorts: from actual laws and regulations issued by governments, to policies and local regulations issued by basin managers, to social norms that prevail in a given community of users. Some will be regimented as part of the electronic institutional framework specification, but others need to be expressed in a declarative form so that one may reason about them, both off- and on-line, both at design and at run time, and both from the institutional (or legislative) perspective and the agent's individual perspective. Issues that are relevant in this respect range from the choice of expressive formalism to the decision-making strategies that agents might use to comply or disobey regulations. Thus, structural aspects like governance, dynamics of norms (also from the legislative and execution perspectives) as well as criteria to evaluate the effectiveness of norms may and need to be explored in the demonstrator.

Organizational and collective interaction There are good opportunities to study the interplay between formal institutional aspects (laws, ontologies and sanctioned practices), the organizations that enforce or should abide by them and the individuals that form those organizations or participate in the regulated activities. Also, the scenario involves collective actors that may not only have their own social rules for allocating rights and solving conflicts but also become involved in negotiation as collective entities. That is the case, for instance, of the "comunidades de regantes" (agricultural users assocs.) who interact with a municipal government or a power plant to negotiate transfers of rights, or as plaintiffs or defendants in conflicts over the use of water. Once again there is the possibility of studying organizational and institutional dynamics, the way rules become internalized by individuals and the emergence of collective norms. These matters suggest also the opportunity to study collective decision-making, judgement aggregation and other formal and informal ways of social choice. Finally, given the rich sociological content of water use, the scenario should provide enough empirical grounds for playing with notions like trust and reputation, moral authority, power and force that are crucial in practice but have not been thoroughly studied in a MAS context, yet.

negotiations between stakeholders in peri-urban catchment areas when water conflicts arise. Closer to our own approach, the recent effort is project MAELIA (http://www.iaai-maelia.eu), that involves simulation of socio-environmental impact of norms for water and other renewable natural resources and the environment.

Structured and spontaneous conflict A significant part of the proposed framework involves the specification of valid negotiation protocols, as we will see below, and therefore the possibility of studying negotiation heuristics, agent architectures adapted to those negotiation capabilities on one side, and on the other the systematic study of the negotiation conventions themselves. Moreover, the framework includes a space —what we call agreement management— where once an agreement for the transfer of water rights has been reached, contracts are negotiated and executed and agreements and contracts may be contested. While the general process for agreement management is properly regulated, the idea is to leave enough flexibility in the institutional framework so that the general idea of an agent managed contract may be explored in earnest. Likewise, those structured interactions that happen after trading rights are excellent brewing environments to study conflicts (detonators, structure and types) and conflict resolution; in particular, the possibility of using and devising non-conventional forms of on-line dispute resolution.

Simulation environment The engineering of the demonstrator requires sophisticated software tools for specification,construction, testing and monitoring of the on-line market and the participating agents. We plan to attach simulation services to the electronic institution infrastructure along the lines of [ANRAS07] and thus facilitate the coupling of *mWater* as a water use module of sophisticated basin simulators for water use policy purposes. Another outcome we foresee is the use of our demonstrator as a proof-of-concept prototype for the actual water banks (and banks for other natural resources) envisaged in current legislation.

As a whole, *mWater* constitutes a rather complex regulated open multi-agent system. The work we report in this deliverable provides the problem specification, and the analysis and design of the institutional framework for *mWater* prototype #1. We are now developing a richer electronic institution where scenes of the trading tables and the agreement management performative structures will be tailored to the two sources of inspiration of the demonstrator: i) to interaction conventions that are interesting for the testing of ideas developed in other work packages of the AT project, and ii) to interaction conventions that correspond to current practices and legislation. In this process we also improve the social structure of the framework to include specific staff roles for trading and conflict resolution mechanisms, auctioneers, arbiters, mediators, facilitators; as well as collective actors. Evidently, the ontology will need to be enriched and we shall begin to deal with the problems of anchoring dialogical terms (i.e. establishing the pragmatics of constants and relations in the communication language).

Contents

Chapter 1

Introduction

It has been said that clean fresh water will be the ”gold” of the 21st century [HR07]. Only 3% of the Earth's water is salt free. Of that 3%, approximately 2.7% is frozen in polar ice caps or deep underground. This leaves only 0.3% of all the water on the planet available for human use [Gle96, Pan07]. Water scarcity is especially problematic in dry climates such as the Mediterranean. Spain suffers from severe water shortages [HR07].

Countries in arid climates need to find better ways to manage their water. In the next century, growth in urban water use and climate change will stress existing water supplies. Inefficiency and waste are luxuries that water scarce regions can no longer afford. Many attribute inefficient water use to command-and-control policies that dictate water allocations to competing interests. These alleged inefficiencies have led to an exploration of market based policies, including water trading, to increase efficient water use.

In this chapter we describe the normative and policy framework of the water management problem in Spain. The description includes an overview of the different Water Laws that regulate the water management and distribution, paying special attention on the transfer of Water-Rights, Water Markets and their regulation. Finally the Aquifer of the Mancha Oriental is discussed in detail.

1.1 Water management and distribution in Spain

Spain's water policy has changed dramatically in the last twenty years. This rapid evolution has been accompanied by growing water problems. As pointed out by Garrido and Llamas [GL07], the key drivers of change include environmental degradation, growing water demand, climatic change, agricultural policy and economic growth. Consequently, Spain needs to improve its water management to meet the rising demand and decreasing supply of the future. Demand is driven by urban growth in major cities and the burgeoning coastal areas.

While the new demand for water comes from urban and coastal areas, the bulk of

Spain's water still goes to crop irrigation. The Spanish Ministry of the Environment and Rural and Marine Affair (formerly the Ministry of Agriculture) estimates that Spain dedicates 70-80% of its water to agriculture.

Spain water policy uses traditional forms of water management, which often allocate water through a politically negotiated process or command-and-control. But it also allows water rights transfer to equal or higher priority right holders (1985 Water Law). The following sections reviews the different Spain's water laws, beginning in 1985, and ending in 2007. The content of these sections are transcribed from [GL07] and the "Real Decreto Legislativo 1/200, BOE 176" (Water Law of the National Hidrological Plan).

1.1.1 The 1985 Water Law and 1999 Water Law reform

The 1985 Water Law opened a new era for water policy for a number of reasons: (i) water resources were considered public domain, saving a few exceptions of groundwater use; (ii) it laid down water planning principles that eventually would be materialised in three failed attempts of national hydrological plans; (iii) it consolidated a financial regime for water users which delivered them important benefits, the irrigators being the most favoured; (iv) it consolidated the institutional role of the Basin Agencies, granting them autonomy, financial resources and personnel to become the actual decision makers in all issues within the basin boundaries; lastly, (v) it defined a model of co-decision making in which direct water users and interested administrations have had an active role in all water planning and management at basin level.

The 1999 Water Law reform amended the 1985 Water Law, changing three fundamental issues. First, it was the regulation of the exchange of water rights, permitting right-holders to engage in voluntary water transfers and the Basin Authorities (Organismos de Cuenca) to setup water banks or trading centers in cases of droughts or of severe scarcity problems. Second, it focused on the creation of public corporations in building water works and recouping the costs by means of sounder financial arrangements. Third, a crucial, thought subtle, consideration of desalinated and reused water as belonging to the public domain, on equal level to other water sources, and the issuance of special water rights granted to its users. The first issue was clearly the most controversial.

1.1.2 The 2001 and 2004 Laws of the National Hydrological Plan

These two laws approved and repealed a major inter-basin water transfer project, the so called Ebro water transfer. While many other initiatives approved in the 2001 NHP (National Hydrological Plan) were maintained in the 2004 NHP and have already been partially implemented, the Ebro transfer epitomizes the breakdown of consensus of a century-old mode of thinking, planning and executing water policies.

As recent as in 2007, the approval of the reform of the Autonomous Statutes of Catalo-

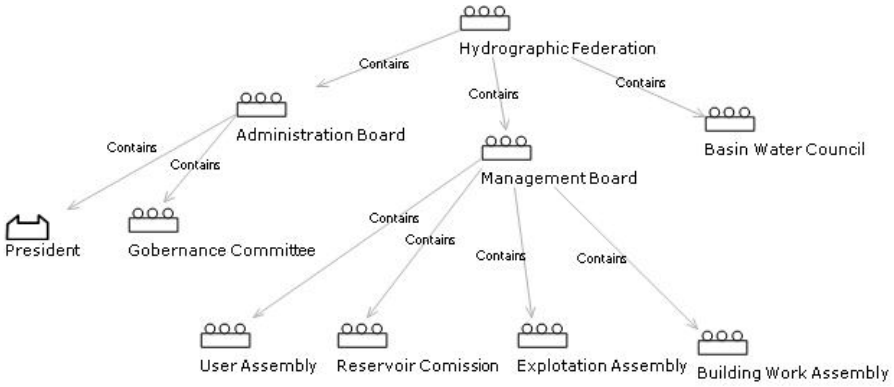

Figure 1.1: Basin Organism organizational structure

nia, Andalucia, Aragon and Valencia consolidated the power of the regional governments on water affairs.

The NHP defines the management structure of the Spain Water policy. Some relevant articles are the followings:

Article 15 of 2001 NHP defines a Hydrographic Basin as the territory in which the water flows to the sea through a network of secondary channels that converge into a unique main channel. The Hydrographic Basin as a water management unit is atomic.

Article 19 of 2001 NHP defines the National Water Council as the higher consulting organism on water subjects. The National Water Council is made up of the Government Administration, the Autonomous Communities, the local entities, the basin authorities, and the most representative professional and economic organisms related with water usages.

Article 21 of 2001 NHP states that a Basin Organism is constituted in the Hydrographic Basins that exceeds the territory of an Autonomous Community.

Among the duties of a Basin Organism is (Article 24) the "... execution ... of plans, programs and actions with the goal of an adequate management of the water requests, in order to promote saving and socio-economical efficiency in the different water usages ..."

The Basin Organizational Structure as depicted in Figure 1.1. A Basin Organism or Hydrographic Federation is composed of three main boards. The Governance board of the Basin Organism (Article 26) is made up of the Governance Committee and the President. The Management board is made up of the User Assembly, the Reservoir Commission, the Exploitation Assembly and the Building Work Assembly. The Planning board is the Basin Water Council.

Article 54 states that the pluvial waters that flow over a property can be legally used by the owner. At the same time the spring waters can be also used by the property owner whenever this usage are less than 70.000 cubic meters.

Article 59 on the water right granting states that every privative use of water that is

not included in Article 54 is subject to administrative granting. The concessions will be granted taking into account the rational use of ground and underground water. Every concession will be granted following the NPH, it is for a finite period of time and not longer than 75 years.

Article 60 on the preference ordering for water usage. A preference ordering should be defined in every Basin Hydrological Plan. Every concession is subject to unavoidable expropriation, in favor of other use that precedes it in the order defined by the Basin Hydrological Plan. In the absence of this order the following will apply:

1. Human water supply and reduced-consumption industries
2. Irrigation / agricultural sectors
3. Industrial usage for energy supply
4. Other industrial uses not included above
5. Aquiculture
6. Leisure uses
7. Navigation and aquatic transportation
8. Other uses

The water right or water concession can be transferred among right-holders. The following section focuses on its regulation and its properties.

1.1.3 Water Right Transfer in Spain

The NHP regulates the water right transfer defining the transfer agreement features and effects. Tradable water rights are rights to use water that can be transferred all or in part, separately from the transfer of land [RR94]. Proponents of water trading also emphasize the importance of property rights since markets can only work when these rights are clearly established [Pan07]. The lack of tradable rights has been cited as a primary source of inefficiency in water markets. If a farmer cannot sell their extra water allotment of water, (s)he has no incentive to use the existing allotment efficiently and it may become wasteful [HR07].

Article 67 of NHP states that any water right-holder can temporarily transfer to other right-holder of the same or higher preference order in the Basin Hydrological Plan (or NHP), obtaining previously an administrative authorization. The preference ordering could not be applied when there is an exceptional situation and it is authorized by the Ministry of Environment.

The water right transfer agreements must be signed and submitted to the Basin Organism and the User Assembly within 15 days (Article 68). The Basin Organism has one month to answer it. If the Organism do not reply to the agreement within one or two month (for right-holders of the same basin, or from different basins, respectively) it is considered authorized.

Article 69 states that the water right transfer can have an associated economic compensation. The amount will be agreed between the negotiating parties and must be included in the right transfer agreement. The Basin Organism can regulate a maximum amount for economic compensations. Water banks or trading centers are defined in Article 71.

Although the Water Law reform opened the era of water markets in 1999, the first experiences took almost seven years to occur. The Law opened two routes to enable right-holders to lease out their rights either to basin authorities or to another user. The simplest way just takes an agreement of two right-holders and their decision to file a permission to formally exchange the right. Very few, albeit significant, exchanges have been reported.

Spain has implemented smaller scale water trading schemes. Take for example, the Irrigation Subscribers Association of the Riudecanyes Reservoir which has traded water rights among its members for decades. Located in the northeastern region of Catalonia, the Association was founded in 1904 when they gained a water concession from the Spanish Government. With 10% privately raised capital, they constructed a dam and channel to irrigate their fields. The remaining funds came as a subsidy from the Spanish government.1 As part of the concession agreement 2/3 of the water was to be used for irrigation and the remaining 1/3 was for municipal water use for the city of Reus. From the outset, the members of the association were allowed to temporarily or permanently sell their water rights to other members of the association. With not enough water to irrigate every agricultural plot, the water trading scheme generated incentives for efficient water use, movement to the production of more valuable crops and increased flexible production. This case presents an interesting institutional arrangement that suggests that water trading can be successfully implemented even when the State still owns the water. In this case, the Association owned the concession but then allowed for usufruct rights to be traded among its members [MK99]. The successful features of this water trading included: the existence of a user-based management approach; water use rights that were well defined, measurable and enforceable; and adequate knowledge about the amount of water available for trading [MK99].

While economists overwhelming agree that water trading can create efficiency improvements, very few countries have actually implemented such policies [CG06]. Only Australia, the United States and Chile are consistently cited as success stories. This suggests that large obstacles to implement water trading have not yet been overcome. These obstacles include [HR07]:

- transaction and infrastructure costs,
- equity considerations,

- distributing water rights among users,
- demand feedbacks effects,
- and drought management issues [Pan07].

Proponents of tradable water rights argue that command-and-control policies are inefficient mechanisms to allocate water resources. Resources are inefficiently distributed when they can be reallocated to improve social welfare. Economists use the term Pareto Optimality to describe the condition of economic efficiency. When resources are put to their most efficient use no trade or redistribution among users can squeeze out any more social value. The concept of Pareto Optimality is critical because it underpins the central argument in favor of water trading. At their core, proponents for water trading are arguing for a redistribution of resources that brings society closer to Pareto Optimality.

While command-and-control policies are likely to bring about an inefficient distribution of water, water markets have their own problems. There are at least three market failures associated with water resource management: (i) externalities, (ii) under-pricing, and (iii) open access [Pan07]. Environmentalists point to the externalities associated with water use. Naturally flowing hydrological systems provide valuable environmental services such as flood control and nutrient and sediment cycling. Diminished water flows disrupts the environmental services provided by rivers and lakes. As a result, water use is under-priced and over-consumed. There are also externalities involved with agricultural production, such as contamination by fertilizers and pesticides. The third market failure concerns open access which also causes over consumption. To some extent, open access can be resolved by the definition of property rights as mentioned earlier. All three of these market failures add complexity for policy makers seeking to move away from command-and-control policies toward market oriented approaches. These market failures suggest that a pure market solution is unlikely to generate a socially efficient outcome. Instead, the challenge will be integrating market mechanisms into existing or new institutional arrangements [HR07].

1.2 The Aquifer of the Mancha Oriental

The Aquifer of the Mancha Oriental (Hydrogeological Unit 08-29 of the Jucar system [FPGMnR04]), also known as the Eastern Mancha Aquifer, is located in the river Jucar basin in the south-east of the Iberian Peninsula (see Figure 1.2). The aquifer has a surface of 7,421 km^2, with a permeable surface of 3,625 km^2. The main tributary is the Cabriel river that flows directly into the Jucar, and a number of minor rivers which do not flow directly into the Jucar, but through infiltration into the aquifer and through the latter into the river. The whole Jucar system is regulated by three major reservoirs: Alarcón, Contreras and Tous, all of them located outside of the Hydrogeological Unit, as well as by minor dams intended for hydroelectric power generating purposes. The aquifer has, as

its natural drainage, the Jucar river in the stretch between the two reservoirs of Alarcón and El Molinar, whose length is approximately 80 km. This aquifer is the main source of water for urban, industrial and agricultural supply within its area of influence. In a greater extent, the Jucar river has to satisfy the urban, agricultural and hydroelectric demand of a significant part of the Valencian Region. The Unit supplies water for irrigation to about 105,000 ha provided with modern irrigation techniques (mainly sprinkler and centre pivot systems), and for urban consumption, including industrial demand, to a population of over 275,000 equivalent inhabitants. The annual water withdrawal for these purposes is about 450 hm^3 (425 hm^3 for irrigation and 25 hm^3 for urban supply), of which only 60 hm^3 are from surface water, while the rest is extracted from the aquifer [FPGMnR04].

Over the past 30 years, the use of groundwater to supply large surfaces of irrigated land has been the key to agricultural development in this area and has passed from less than 20,000 ha in the 1970s to nearly 80,000 ha in our days [FPGMnR04]. In arid and semiarid zones, irrigation using groundwater has transformed good quality land with low productivity (caused by drought) into areas of high productivity. But the income level for the farmers has increased while the rural population base has been maintained. Consequently, the transformation of dry crop lands in the area of this aquifer into irrigated crop lands, through groundwater capture, has caused precise declines in piezometric levels of the aquifer, which have been continuously decreasing since 1975, as extraction volumes have exceeded recharge water volumes. As a result, the aquifer is now close to overexploitation [FPGMnR04, GL07, MdSODO+07].

An Irrigation Users' Association of Eastern Mancha Aquifer (JCRMO from the Spanish Junta Central de Regantes de la Mancha Oriental) was founded in 1994 by users of the aquifer. This institution includes farmers and any other water user of the Unit with the main aim of achieving a sustainable level of water use. To achieve this aim, various research and technology transfer projects have been developed in the area since 1995 with the participation of teams from universities, especially from Castilla La Mancha University, and technology transfer institutions. The participation of the JCRMO has been crucial for updating technology leading to the solution of several practical problems.

As indicated above, water is mainly used for agricultural irrigation, which accounts for more than 90% of the total water consumed. Irrigators are thus the first element to be taken into account in the management of water resources. Urban and industrial withdrawal accounts for less than 10% of the total use and it is jointly managed, as industrial consumers are connected to the urban network. The bodies acting as representatives in this respect are the town councils and, by delegation, the companies responsible for the supply of drinking water to municipal districts. Finally the environmental use has to be considered, which is represented by the water volume required to ensure environmental and ecological health of the Unit, as well as that destined for sport or recreation. In this respect all the citizens of the community involved would have the right, as well as the duty, of expressing their views. But in practice, the official stakeholders are the Irrigation Users' Association (JCRMO) and the Ministry of Environment (`http://www.marm.es`) along with the environmental Non Governmental Organizations (NGOs). The former is the major user of

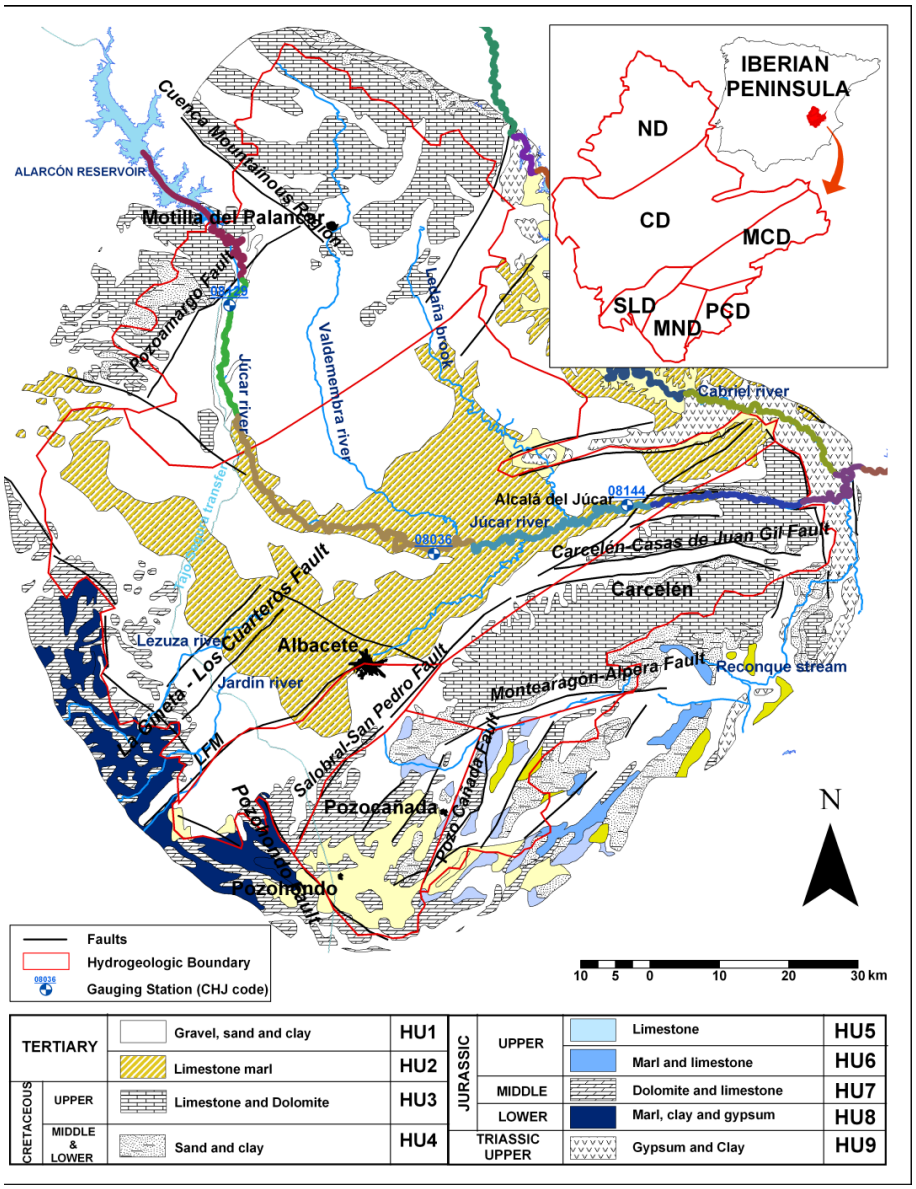

Figure 1.2: Aquifer of the Mancha Oriental in the south-east of the Iberian Peninsula

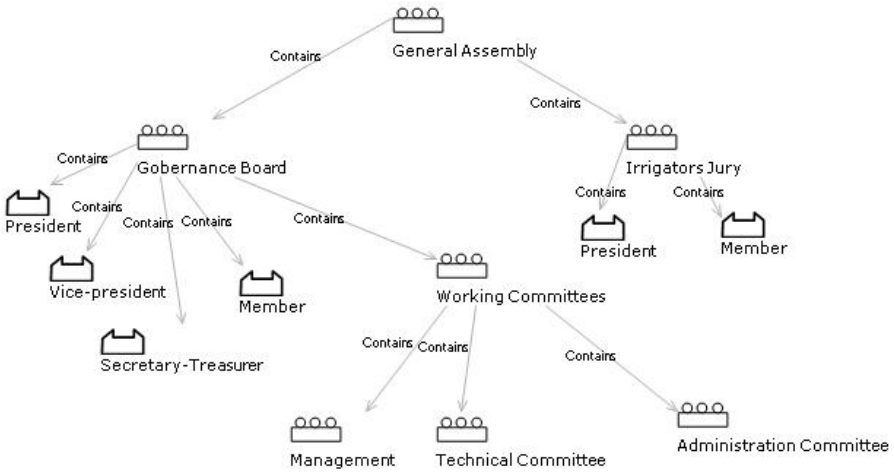

Figure 1.3: User Assembly of the Aquifer of the Mancha Oriental organizational structure

water in the Unit, more than 90%, and gathers all the irrigation farms of the Unit, around 105,000 ha and 920 farmers. The latter is the water authority in the area. Clearly, an integrated management implies taking into account the concerns of all those who are directly interested, for financial, political, social, cultural, or other reasons, in the decisions that may be taken, which provides an excellent opportunity for the application of agreement technologies.

Figure 1.3 shows the organizational structure of the User Assembly of the Aquifer of the Mancha Oriental, whose main goal is to regulate the usage of ground and underground water for irrigation and other uses, and the rational/not overexploited use of the aquifers of the zone. The Assembly will also represent its members against public and private entities in water related cases. But in no case it will interfere in the privative attributions of the Irrigators Community adhered to the assembly.

Any physical or legal person who owns 0.5 hectares of farm-grown or other no-farming users could be members of the User Assembly. The only constraint is that the member must commit to a legal usage of ground and underground water in the regional influence of the community.

The General Assembly is the higher organism of the User Assembly and it is made up by all members of the User Assembly. The Assembly President, the Vice-president and the Secretary will be also of the Governance Board.

The Governance Board is in charge of carrying up the agreements of the General Assembly and its own agreements. The Governance Board can have up to 14 Members, of which 8 are elected by the General Assembly among irrigators, 3 are from the adhered Irrigators Communities, 1 for every possible non farming water use. Every member will have a corresponding substitute.

The Irrigators and other Uses Jury have to be acquainted of the possible problems

that can appear among the User Assembly members. They have to impose the norm's infringers the corresponding sanctions and establish the compensation to the injured party. The jury procedure will be public and oral, and will be regulated by the rules of Irrigation and Use Jury and Article 225 of the Public Domain Hydraulic Rule. The jury has a President (that is a member of the Governance Board) and two more Members. The Jury Secretary will be the Governance Board Secretary.

1.2.1 User Census

The General User Census contains:

- Name of the farm and type of water usage.
- Area of the farm in hectares.
- Delimitation, boundary and usage localization.
- District where it is settled.
- Owner's name.
- Participation in the assembly expenses.

1.2.2 Offenses and Sanctions

Any wrong doing of a member of the General Assembly against other user or the proper assembly is an offense. The following are considered offenses:

- Any action or omission that alter or damage the water usage that belongs to any member, as well as the wrong water exploitation.
- The infraction of any of the rules of the User Assembly, as well as the omission of the duties, and the insubordination to the assembly worker.
- Any action or omission that is detrimental to the User Assembly or its members, although it is not included in its statute.

Any infraction will be judged by the Irrigation and Other Uses Jury. The jury will study and qualify the infraction, will impose the sanction to the infractor and will repair or compensate whenever is required. If the pecuniary sanction is not fulfilled by the infractor user, the assembly can fulfil it, affecting the execution subsidiary cost to the infractor.

1.2.3 Basic norms for the sanction application

The total amount of the sanctions will not be, in any case, greater than the limit defined for offenses in the Spanish Penal Code.

The sanctions will be graduated by the Irrigation and Other Uses Jury, regarding the rules, trying to achieve the same sacrifice to the infractor taking into account its economic capacity and the proportionality principle.

If the offense is the non-payment of the membership fee and other debts, its sanction will be the required payment of the main amount plus a surcharge.

If the infraction causes damages in other users or the assembly belongings, the sanction will be the restitution of them, plus a suitable compensation.

The Rules of the Irrigation and Other Uses Jury, will categorize each offense as light, severe or very severe, concretizing them and defining sanctions.

If the denounced offense was accomplished by a person not member of the Assembly, it will be denounced by the Governance Board to the qualified court.

1.2.4 Basin Hydrological Plan of the Jucar System

By the end of year 2009, the Basin Hydrological Plan of the Jucar System should be defined by the Basin Administration and made it public. The web page `http://www.phjucar.com` publishes draft versions of this plan.

Chapter 2

mWater: Requirement Specification

In this chapter the requirements of the mWater demonstrator are detailed. Section 2.1 defines the purpose of the demonstrator. The scope and applicability of mWater is drawn in Section 2.2. The design statements are stated in Section 2.3. Section 2.4 overviews the relation among the demonstrator and other work packages. Finally, the scope and goals of the mWater prototype #1 is outlined in Section 2.5.

2.1 Purpose of the demonstrator

The purpose of mWater is to test and prove that Agreement Technologies can be successfully used in the construction of a prototype that will address the Water Rights Transfer problem. This application is of strategic importance for the Spanish society and economy. mWater will provide an efficient allocation of water resources based on a system of voluntary trade in water, which brings potentially large benefits to all parties involved. One implication of these complex requirements is the need for flexible on-demand negotiation, initiation, co-ordination, and supervision of various activities represented either through persons, or non-human actors (i.e., agents and services).

mWater will be a virtual market base system [BGGN09, BGG$^+$09, GGN09], in which water right transfer agreements will be executed by autonomous normative entities. In this market base environment different autonomous entities, representing individual or group of irrigators, industries, or other water user entities, will get in contact with water right holders that want to transfer their rights. They will be able to negotiate the terms and conditions of the transfer agreement following the National Hydrological Plan and Basin Hydrological Plan normative laws. At the same time, the Basin Administration entities will be represented in the mWater system as normative and or referee entities that will assure the correct execution of the water balanced distribution and usage. In order to reach the goal of this Work Package task the focus will be on developing a good water right market design that can take into account the dynamics inherent in the water sector

2.2 Scope and Applicability

The water management sector has a large list of very complex associated problems that can take advantages of virtual market base systems for water right transfer. Some of these Agreement Technologies based applications could be:

1. An agreement-based framework of water right markets that takes into account: water markets scenarios; buyers, sellers and third parties; "prices" for water; the mechanism to participate in water right markets; water transportation infrastructure, and; the role of government authorities (normative and/or referee entities).
2. A virtual agreement-based laboratory for studying the dynamic effects of different water market policies on the prices and quantities of water sold in the market. Such an Agreement Technologies based application can make the water market socially optimal, that is, sell rights at prices that reflect the true value of water in the region.
3. A decision support system based on water right transfer agreements that can help the Basin Administration on the evaluation of different management activities. Mediation techniques which require fewer resources will aid the market in discovering a greater degree of allocation efficiency.
4. An evaluation framework to compare agent-based models and mathematical models for water markets.
5. A simulation tool for studying water evolving markets in which different market-shaping elements can evolve and adapt. For example: changing market structures, adaptive negotiation protocols, market model meta-reasoning, etc.

2.3 mWater: Previous Design Statements

As indicated above, the mWater demonstrator aims at formulating a common application example for the assessment of agreement technologies under a multi-agent framework. From the very beginning, the underlying idea is to propose a water market domain in which different stakeholders interact to trade water rights and reach a win-win agreement.

2.3.1 Water markets and banks

The term of water market can be defined as an institutional, decentralized framework where users with water rights (right-holders) are allowed to voluntarily trade them, always fulfilling some pre-established rules, to other users in exchange of some compensation, economic or not [Cal06, RGL04, Tho97]. In general, water rights are transferred only under temporal basis; this means trading water physically only within a time period, but

the right-holders keep their rights. This is done in such a way to avoid creating new right-holders.

Water markets can allow rapid changes in allocation in response to changing demands for water and can stimulate investment and employment as users are assured of access to secure supplies of water. Because of water's unique characteristics, such markets do not work everywhere, they are not homogenous as present different organization schemata, nor do they solve all water-related issues [Tho97]. Therefore, it is essential to design appropriate water laws and regulate, either privately or publicly, the users' actions, interactions and their eventual trade. By doing this, water markets can effectively address rising demands for groundwater and for surface water found in rivers, lakes, and canals. In that line, international experience in USA (particularly California), Chile, Australia or Mexico has demonstrated that (formal) water markets can improve the economic efficiency of water use and stimulate investment [RGL04, Tho97].

On the other hand, a water bank might be considered like a financial bank (or credit cooperative) that facilitates exchanges among users, members or right-holders who want to buy (borrow) and those who want to sell (deposit) [Jae]. In the case of a credit cooperative, the institution may be little more than a clearinghouse that makes the exchanges easier among members and charges a small fee to cover its operating costs. Financial resources are transferred from those who deposit funds for a price (interest earned) to those who pay (in interest) to borrow funds. An independent water bank could operate in much the same way, with limited involvement or funding by government. The willingness of irrigators to buy or sell water highly depends on the difference between the price of water and net revenue each farmer expects to earn by irrigating. Thus, for a given price of irrigation water, a farmer would be willing to purchase water if (s)he expects a unit of water to generate more incomes than it costs. If another farmer expects a unit of water to earn less that (s)he could sell it for, (s)he might want to sell it. If all farmers earned the same net revenue per unit of water, little would be gained from water transfer [Jae]. Nevertheless, a water bank can also be used in exceptional situations of drought periods or aquifers' over-exploitation [Cal06]. In such a case, the water banks are managed by the basin organisms, thus making public offers of water rights to give them back to other users. Here, the price is established by the organism itself, in order to promote a higher transparency in the transfer of rights and to create a more dynamic scenario.

2.3.2 Some market scenarios

At this point, we present several market scenarios to be used in the mWater demonstrator. We start from a simple scenario and progressively we make it more complex.

Scenario #1. Water markets among water users of the same basin

The simplest scenario of a water market is the one created for the members of the same basin. In essence, it comprises the temporary transfer of water rights from one right-holder to another after reaching an agreement in terms of the right to be transferred and the economic compensation associated to such a transfer [BGGN09, BGG$^+$09, GGN09].

The stakeholders are formed by all the users (members) of the basin (see section 1.1.2 for all current water uses), together with the administrative organisms of the basin and, when necessary, the associated Ministry of the Environment. The water market in Spain is strongly regulated and imposes several constraints. Firstly, water rights can only be transferred between users of the same or higher preference order defined by the Basin Hydrological Plan, as introduced in section 1.1.2. For example, irrigation rights can only be transferred for alternative irrigation or human water supply but not for industrial uses. Furthermore, in this scenario we focus just on irrigation rights and do not consider water trading for industrial uses, aquiculture, leisure or navigation. Secondly, non consumptive rights can only be transferred to other non consumptive uses. Finally, both parts of the transfer (the seller and the buyer) must have the concession of the water right in property, thus preventing non-holders from participating in the market. This means that in our scenario only users that have previous irrigation rights can participate in the market[1]. A water right usually represents an amount of water that can be pumped out of a river, canal, aquifer, etc. during a whole season or harvest. For instance, a particular water right could allow its holder to pump out up to 10 m^3 of water per day during the next cotton season.

The two right-holders that participate in the market are allowed by law to establish the economic compensation by means of a private agreement process, signing a formal contract that is used as an official record. This record is publicly available to the other members of the basin in case some of them want to allege its applicability, i.e. when this transfer is detrimental to a third party, it can complain against this transfer. In such a case, the administrative organisms of the basin study the effects of the transfer and decide whether it is finally applicable.

In most cases, the transfer of water does not need particular infrastructure as the river or the canal itself is used to move water from the seller to the buyer. However, when water requires third parties' infrastructure, its use must be freely agreed by the three parties: seller, buyer and infrastructure's owner. If the infrastructure elements belong to the basin organism, both the seller and the buyer need to ask for their use to the organism, which determines the usage fee. In any case, the transportation cost of the transfer needs to be included in the final cost of the water transfer. According to the European water framework directive, the idea of this usage fee is to charge final users with the real cost of infrastructure and environmental impact without affecting negatively to the efficiency of the market. In general, this efficiency is measured in terms of economic issues to

[1]Obviously, this restriction limits the potential of the market's benefits and the efficiency of the water use [Cal06]. A straightforward extension could remove this restriction and allow any user at any level of water use, with or without previous water rights, to participate in the market.

reallocate water to the highest value uses [RGL04, Tho97]. But, in this scenario we can consider also the social benefit in order to achieve socially optimal solutions.

We can make this scenario more flexible by including two extensions. In the former, it is possible to consider both the seller and the buyer as grouped entities, i.e. instead of having only one member playing the role of seller/buyer, a set of members may join together to participate in the market at a higher scale. For instance, a given seller has a water right of 2 m^3 per day, which is clearly insufficient for a buyer that needs 10 m^3 of water. If more sellers are grouped it would be possible to have water rights to fit the requirement of the buyer, which analogously can be grouped in a larger buyer entity. Now, the stakeholders of this scenario will need to take into consideration the seller/buyer entity and model the interactions among the particular members of each entity. In the latter, we can make differences among the water rights to be traded depending on the river section. For instance, upstream water can be more valuable than downstream as its quality is significantly better.

Finally, it is important to note that this scenario has been entirely placed within a formal setting, where: (i) a contract is signed, (ii) and economic transaction is performed in the form of a compensation, and (iii) a record is publicly available in the given organisms to third parties. However, there exists a long tradition among irrigators of the same basin to participate in informal, i.e. non-officially regulated, markets. In such a case, water trading is seen as a punctual, locally trade of water amounts without monetary transactions (the two members exchange irrigation shifts, particular farm machinery, etc.) and rely on informal agreements based on previous trust [Cal06]. Although, obviously there is not an official regulation here, this type of market is very usual in the regions of Valencia and Murcia (east coast of Spain).

Scenario #2. Water markets among water users of different basins

This scenario extends the scenario #1 by allowing water users of different basins to be involved in the same water market. The description of the previous scenario is fully valid here, but now the stakeholders are members of different basins and the administrative organisms are those of all the basins with active members in the market. When different basins participate in the same market it makes it more necessary to have a higher governor entity, which is the Ministry of the Environment. This scenario works in the same way as scenario #1 but, as there exists a higher number of stakeholders, the number of interactions is much higher.

Furthermore, since the scope of this market is clearly broader than in scenario #1, two restrictions need to be fulfilled. First, the market is created under a formal basis, i.e. informal markets are not possible here. Second, water trade is subject to the availability of infrastructure for water transfer, which usually entails a higher transportation cost, and strongly regulated by the National Hydrological Plan.

Scenario #3. Water banks

In Spain, water banks are activated in exceptional situations of drought periods or aquifers' over-exploitation [Cal06]. A water bank is strongly regulated and managed by an exchange bureau, either private or public. Because of the extreme situation where water banks are activated, several situations are possible:

- The basin organisms have the legal authority to create public offers for acquiring water rights and transfer them to other users at a price established by the organisms themselves. The idea here is to facilitate the relations between sellers and buyers, reducing the cost of the transactions and promoting a more transparent scenario. Note that by doing this, the administrative organisms have the opportunity to buy rights despite not having concessions of water rights in property.
- The water market that is created comprises different basins, like in scenario #2, and it is common that the users are exempt from paying the water transportation cost, which comes from using public infrastructure and it is, consequently, charged to the public budget. The problem here arises because of the third-party effects [Jae], which in some cases include political fights that might limit potential transactions.
- The apparition of a private or public intermediary can improve the efficiency of the water trading process [RGL04]. As these intermediaries know perfectly who supply and demand water, and which is the easiest way of transporting it, they can introduce more agility in the market. In this case, there exists a new stakeholder that is not strictly a buyer/seller nor is a right-holder, but plays an active role in getting a better efficiency in the market.
- Some users, for instance irrigators, join together to form a bigger community to buy arable land in the same, or other basins, and thereby acquiring its water rights. Formally speaking, this is not a temporal transfer of water rights but a transaction of buying a permanent right that is associated to bought land.

In this scenario we can relax the situation for activating a water bank, making it more flexible, and use it in drought or wet periods, as usual in many other countries such as USA, Chile or Australia. The main reason for doing this is that it can promote a better use of water [RGL04, Tho97].

Scenario #4. Water brokers

Under the idea of 'first the stock market, now water' a new scenario can be opened. In this last scenario, water policy mirrors the economic policy by creating transaction agencies (brokers) where users make public their needs of selling or buying water rights. This agency fits the necessities of buying and selling at competitive prices under the law of

supply and demand, similarly to the stock market. As in scenario #3, this type of private agency acts as an intermediary and, though it is a new stakeholder, it does not really sell nor buy any water right. Also, depending on the type of agency it may include an additional fee to the water transaction, or nothing in cases of non-profit making agencies.

Finally, a more complex scenario can be modeled in the line of a futures market. The underlying idea is that a stakeholder (a particular one or some of them in a community) buys some water rights to a seller based on some unknown circumstances in the future. For instance, a buyer borrows the right to use 10 m^3 of water per day during the summer season if (s)he really needs that water, e.g. in absence of rainfall during the summer. This means the buyer has to pay a fixed fee to the seller for the mere fact of having that future right and, if this right is finally used, the buyer must pay the seller the water that is transferred at an agreed price. The advantages of this scenario are twofold. First, the buyer has the guarantee of having water independently of the rainfall, that is, the buyer pays for a kind of insurance on water availability and later pays for the water that is really consumed in the transfer. On the other hand, the seller receives a fixed amount of money for the right to use his/her water and an additional compensation if that water is used; but if finally not all that water is consumed by the buyer, (s)he can still use the remaining water. This setting is very interesting for both stakeholders, but includes a more dynamic behavior in the scenario and certain uncertainty that needs to me managed in the future.

2.4 Interaction among mWater and other AT WPs

In this section we draw the relationship among the different Agreement Technologies Working Packages and the mWater functioning and components. Figure 2.1 shows the different technologies that mWater will require from the AT WPs. These elements will be integrated in the different components of the mWater prototypes.

2.4.1 Technology challenges of mWater

The first design of mWater presented in previous section leads us to believe that mWater is an interesting sandbox for AT. But how can we use it for testing agreement technologies? Some key issues on using AT notions in mWater are discussed here.

Organizational models, structures of basins and organisms, and ontologies for negotiation (WP1 and WP4) that must be dynamic and flexible enough to specify versatile and regulated market scenarios. Because water's unique characteristics, such markets do not work everywhere; they are not homogenous as they present different organization schemata. mWater requires organization structures that restrict the way agreements are reached by fixing the social structure of the participating entities (taking into account for example the NHP): the capabilities of their roles and the relationships among them (e.g. power and authority). Therefore, we need flexible models that can be easily extended.

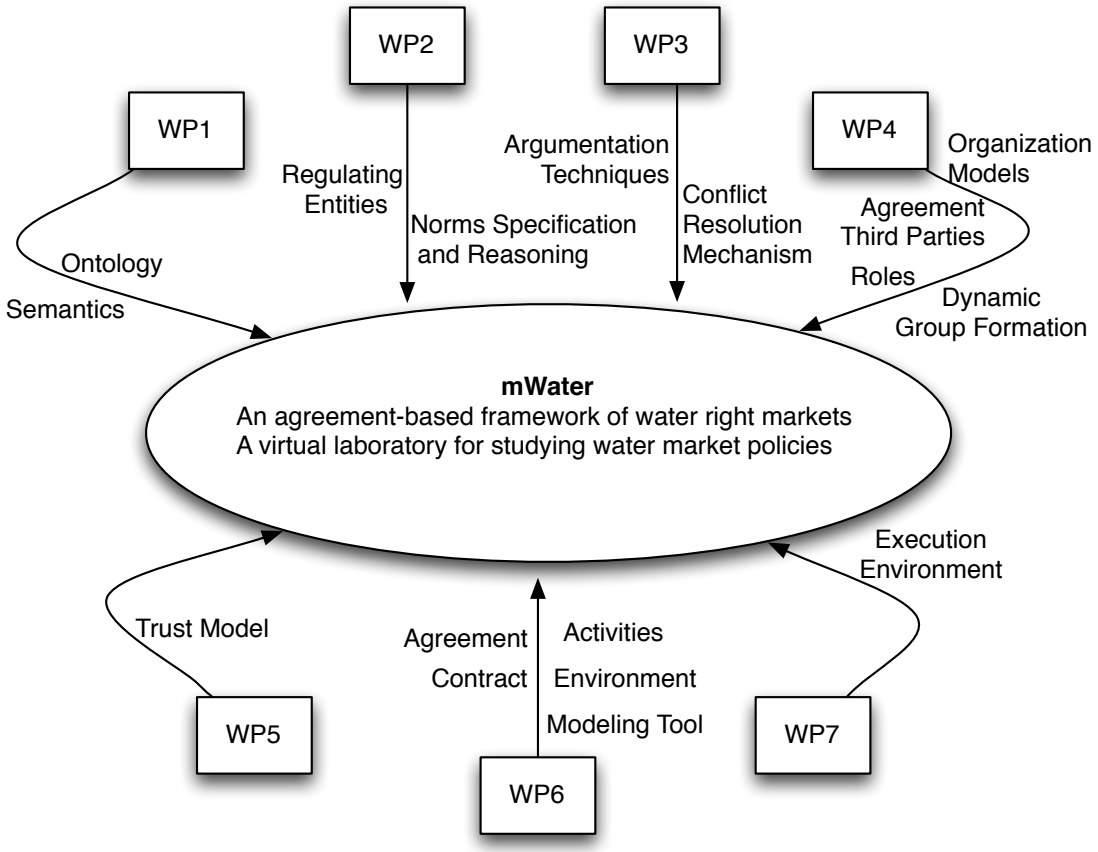

Figure 2.1: Interaction among mWater and other AT WPs

Normative regulation for negotiation and execution of agreements and contracts (WP2 and WP7). It is essential to conform to the water laws and market norms, and to regulate the users' actions, interactions and their eventual trade within the scope of the market execution. Declarative semantics are required to specify and represent obligations and prohibitions over roles, or over the combination of components. A normative framework is required to specify and guarantee the constraints of the water right agreements, and the processes to reach them.

Techniques for flexible on-demand individual and collective negotiation of humans or non-human actors (i.e., agents and services). It is often the case that a water right holder is motivated to achieve a goal (buy or sell its right) that is only possible by gaining the collaboration of other elements (i.e., a federation of water right holders). In other words, we will probably need to deal with an aggregation of opinions (WP3) for conflict and grievance resolution, and their further application. It is also possible to require planning techniques for service composition, thus reaching a common agreement. In such cases, it is required to generate an explicit mutually acceptable agreement through negotiation and to define detailed workflows that regulate the activities and combinations of roles in

the organization, as well as their associated data flow. mWater demands also models and techniques for judgement aggregation, argumentation, persuasion, normative reasoning and agreement planning. Additionally, models for agreement patterns specification are also important. Relations among different agreements (sub-agreements), for example a situation in which in order to get a water right transfer a buyer requires to contract a transportation resource from other users. Specification and negotiation of contracts in terms of preambles, operative part, conditions precedent, operative provisions, and other agreements or contract annexed, etc.

Techniques for initiation, coordination, and supervision of different forms of agreement, contracts and grievance (WP6). This is also closely related to trust models (WP5) that may affect the negotiation modes (WP2 and WP3) and the contracts themselves (WP6). For instance, when trust levels are high, users may do without signed contracts. On the contrary, when trust is scarce, a signed contract will be essential. But even when water right agreements or contracts are signed, the behavior of the participating entities might not be completely determined as their autonomy and selfishness might cause them not to honor their commitments if there is a potential gain in doing so. An approach is required to deal with it.

Finally, an approach to summarize the history of agreements and subsequent agreement executions in order to build long-term relationships between the water right market participants is also required.

2.4.2 A fertile Case-Study for AT

The following is a sketch of four study themes that, we believe, make the *mWater* framework a fertile case-study for the testing and development of agreement technologies, as presented in [BGGN09, BGG$^+$09].

A regulated environment. The *mWater* scenario requires the expression and use of norms and regulations of different sorts: from actual laws and regulations issued by governments, to policies and local regulations issued by basin managers, to social norms that prevail in a given community of users. Current regulations impose certain constitutive restrictions, like the total order on seven very specific types of water use, that may be readily regimented into the institutional specification. Likewise for procedural requirements (for instance, the Ministry's acknowledgement before a transfer becomes active). However, there are regulations that should not be regimented that way and should be expressed in declarative form in order to guarantee some formal properties, and comply or enforce them after some situated reasoning. Then, there is the problem of expressiveness: the type of norms we have dealt with so far have straightforward formal representations that are amenable for formal and computational manipulation but, as the literature in the field shows, questions and alternatives abound. As can be noted, some norms will be regimented as part of the electronic institutional framework specification, but others need to be expressed in a declarative form so that one may reason about them, both off-

and on-line, both at design and at run time, and both from the institutional (or legislative) perspective and the agent's individual perspective. Issues that are relevant in this respect range from the choice of expressive formalism to the decision-making strategies that agents might use to comply or disobey regulations. Thus, structural aspects like governance, dynamics of norms (also from the legislative and execution perspectives) as well as criteria to evaluate the effectiveness of norms may and need to be explored in the demonstrator [CAJB09, CAB09].

Organizational and collective interaction. There are good opportunities to study the interplay between formal institutional aspects (laws, ontologies and sanctioned practices), the organizations that enforce or should abide by them and the individuals that form those organizations [AGV+04, APA+07, HGPRG+09] or participate in the regulated activities. Also, the scenario involves collective actors that may not only have their own social rules for allocating rights and solving conflicts but also become involved in negotiation as collective entities. One immediate extension is to capture all those roles currently recognized by legislation that have any impact on trading, agreement management, grievances and conflict resolution. That is the case, for instance, of the "comunidades de regantes" (agricultural users associations) who interact with a municipal government or a power plant to negotiate transfers of rights, or as plaintiffs or defendants in conflicts over the use of water. Once again there is the possibility of studying organizational and institutional dynamics, the way rules become internalized by individuals and the emergence of collective norms. These matters suggest also the opportunity to study collective decision-making, judgement aggregation and other formal and informal ways of social choice. Similarly, we want to study the roles and operations of non-trading organizations that somehow affect demand (e.g., water treatment plants, water distribution companies, municipality services, water transport firms and infrastructure). Finally, given the rich sociological content of water use, the scenario should provide enough empirical grounds for playing with notions like trust and reputation, moral authority, power and force that are crucial in practice but have not been thoroughly studied in a MAS context, yet.

Structured and spontaneous conflict. A significant part of the proposed framework involves the specification of valid negotiation protocols, as we will see below, and therefore the possibility of studying negotiation heuristics, agent architectures adapted to those negotiation capabilities on one side, and on the other the systematic study of the negotiation conventions themselves. Moreover, the framework includes a space —what we call agreement management— where once an agreement for the transfer of water rights has been reached, contracts are negotiated and executed and agreements and contracts may be contested. While the general process for agreement management is properly regulated, the idea is to leave enough flexibility in the institutional framework so that the general idea of an agent managed contract may be explored in earnest. Likewise, those structured interactions that happen after trading rights are excellent brewing environments to study conflicts (detonators, structure and types) and conflict resolution; in particular, the possibility of using and devising non-conventional forms of on-line dispute resolution.

Simulation environment. The engineering of the demonstrator requires sophisticated

software tools for specification [JB04, BJC+06, SJR+02, GB04b], construction, testing and monitoring of the on-line market and the participating agents. We plan to attach simulation services to the electronic institution infrastructure along the lines of [ANRAS07] and thus facilitate the coupling of *mWater* as a water use module of sophisticated basin simulators for water use policy purposes. Another outcome we foresee is the use of our demonstrator as a proof-of-concept prototype for the actual water banks (and banks for other natural resources) envisaged in current legislation. Further developments include a more robust information model for a better handling of privacy and collective speech acts: a systematic treatment of scene splicing (to have modular add-ons); proactive interventions in AMELI, so that prohibitions, obligations and the invitation and expulsion of agents may be instrumented through scene managers; and a generic human interface service that map governor interactions with an external agent into a human-web-user interface.

2.5 mWater prototype #1

mWater prototype #1 will address Market Scenario #1 of Section 2.3. Subsequent mWater prototypes will add other market scenarios in order to get the full mWater prototype by the end of the AT project.

Chapter 3

Analysis of mWater prototype #1

In this chapter the analysis of mWater prototype #1 is detailed. In Section 3.1 we identify the goals of the Market Scenario that will be implemented in prototype #1. Section 3.2 describes the stakeholders, whereas the roles and organizational structure of the market scenario are presented in Section 3.3. The different market-shaping elements are described in Section 3.4. The detailed activities of the scenario are analyzed in Section 3.5. Finally, the performance and quality criteria for this market scenario are presented in Section 3.6

3.1 Market Scenario Goals

The following are goals of the Market Scenario implemented in mWater prototype #1:

- All the water right transfers executed in mWater should attain an ecological balance of water resource use.
- mWater will come to an equity distribution of water among its different water users.
- The different playing roles of the market scenario will try to maximize their pecuniary compensations.

Figure 3.1 depicts the goals of mWater #1 and its stakeholders, which are deeply explained in the next section.

3.2 Stakeholders

mWater prototype #1 has the following stakeholders:

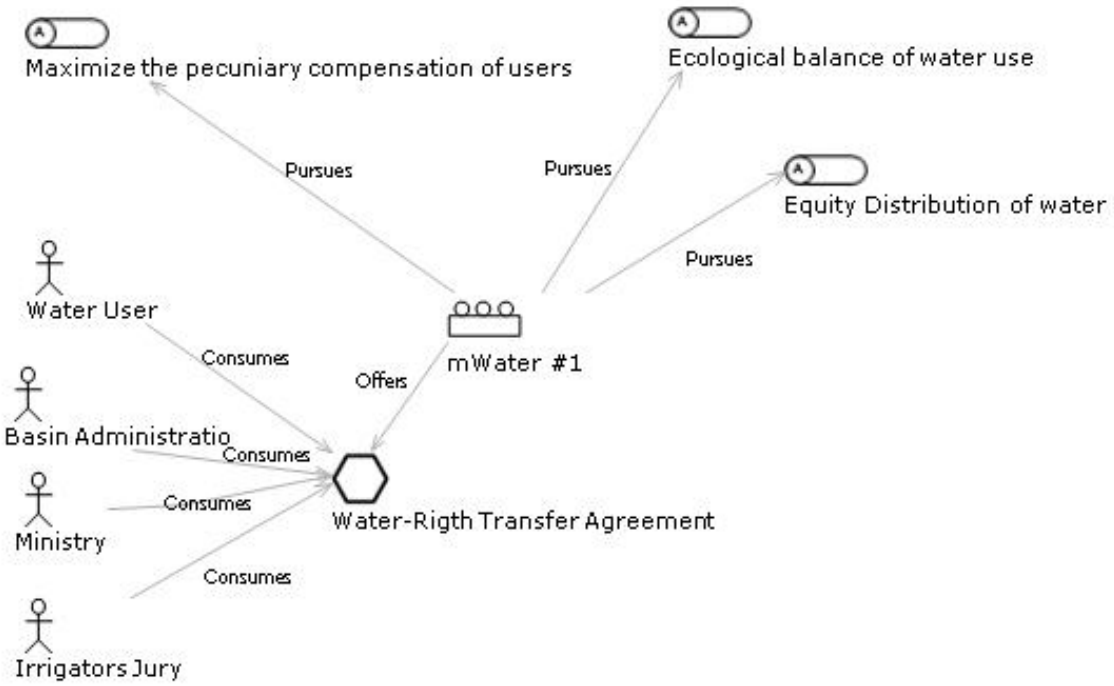

Figure 3.1: mWater #1, goals and stakeholders

- **Water users of the User Assembly**: A water user is a water right holder. The different type of water uses define the water users, which are:
  - **Human water suppliers**: a company that supplies water for human consumption, and low consuming industries.
  - **Irrigators**: owner of a property that uses water for agriculture.
  - **Power companies**: a company that produces electricity by means of hydraulic power.
  - **Industries**: other industrial uses that are not included in the first point.
  - **Aquiculture Users**: water use for growing plants (without soil) in water containing dissolved nutrients.
  - **Leisure Users**: sport and leisure uses of water.
  - **Navigation and Aquatic Transportation**.
- **Basin Administration**: the Hydrographic Federation representative for assuring an adequate management of the water requests, in order to promote saving and socio-economical efficiency in the different water uses.
- **Ministry of the Environment and Rural and Marine Affair**: it is the major authority on water uses regulation.

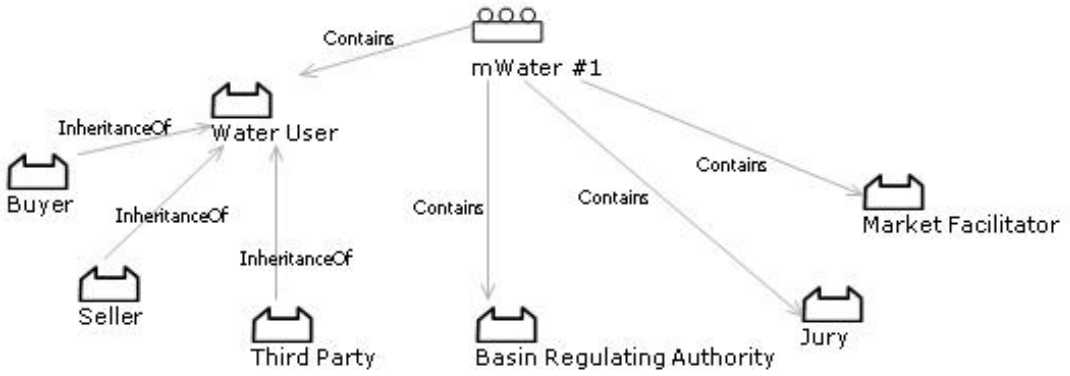

Figure 3.2: mWater #1 roles and organizational structure

- **The Irrigators and other Uses Jury**: this jury have to be acquainted of the possible problems that may appear among the User Assembly members.

3.3 Roles and Organizational structure

In this section the different playing roles of the market scenario are cited. The first four are internal roles, whereas the other three are external ones.

- **Water User**: a water right-holder of the basin.
- **Buyer**: a Water User that wants to transfer its right and or buy a transportation resource.
- **Seller**: a Water User that wants to purchase rights and or sell a transportation resource.
- **Third party**: a Water User that can be affected by a water-right transfer agreement.
- **Basin regulating authority**: the Basin Administration representative that can authorize a water-right transfer agreement.
- **Jury**: the referee entity in problems among the contracting parties and (possibly) third parties of a water-right transfer agreement.
- **Market facilitator**: a management entity for assuring the execution of the different activities (see Section 3.5) in the market scenario.

The roles of the market scenario and the organizational structure are outlined in Figure 3.2.

3.4 Market-shaping elements

The following subsections describe the market-shaping elements that configure the market scenario of mWater #1.

3.4.1 Market ontology

The following are the ontology concepts of the market scenario of mWater #1.

- **Water**: The attributes that define a water resource are:
  - Type of water.
  - Source (river, dam, underground).
- **Water user**: The attributes that define a water user are:
  - Name of the farm.
  - Area of the farm in hectares (ha).
  - Delimitation and boundary localization.
  - District where it is settled.
  - Owner's name.
  - Participation in the assembly expenses.
  - Water volume.
  - Type of water (usage).
- **Water-right**: The water-right is defined by:
  - Basin.
  - Water user.
  - Water volume.
  - District where it is settled.
  - Time Period.
  - Type of water.
- **Water-right transfer**
  - Water user.
  - Type (offer, demand).
  - Water volume.

  - District where it is settled.
  - Time Period.
  - Type of water (purified, underground, etc.)
  - Water Price.
  - Associated water-right.

- **Water-right transfer agreement**
  - Seller.
  - Buyer.
  - Water-right transfer.
  - Agreement date.
  - Status (Published, Authorized, Not-Authorized, Executed).
  - Price.
  - Associated agreements.

- **Transportation resource usage agreement**
  - Seller.
  - Buyer.
  - Resource.
  - Time Period.
  - Usage
  - Price.

- **Water price**
  - Liters.
  - District where it is settled.
  - Time Period.
  - Type of water.
  - Price.

- **Denouncement**
  - Denouncer.
  - Reported.

  - Associated Water-right transfer contract.
  - Offense
  - Denouncement Date.
  - Status (Pending, Executed)

- **Sanction**
  - Accused
  - Denouncement
  - Amount of the sanction.
  - Status (Pending, Executed)
  - Sanction Date.
  - Type (Light, Severe, Very severe)

- **Transportation resource**
  - Owner.
  - Resource type.
  - Basin.

- **Source**
  - Name.
  - Water.
  - Location, basin(s) in which it is located.
  - Source Type (river, dam, ground water).
  - Capacity.

3.4.2 Resources

Obviously, the main resource in mWater is water, but it is not the only one. There are different water sources which are also resources of the system, and the transportation infrastructure that connects different sources and allows water flow.

- **River**. A natural watercourse, usually freshwater, flowing toward an ocean, a lake, a sea or another river.
- **Dam**. A barrier that impounds water or underground streams.

- **Underground Water**. Water that is subterranean.

- **Transportation infrastructure**. The transportation network that allows water flows. It can include rivers, canals, pipes, waterways, watercourses, wells, and their connections.

3.4.3 Water pricing factors

Water is scarce in many contexts (drought, degraded quality, etc.), so water pricing is increasingly seen as an acceptable instrument of public policy. Water-use charges, pollution charges, tradable permits for water withdrawals or release of specific pollutants, and fines are all market-based approaches that can contribute to making water more accessible, healthier and more sustainable over the long term [Jon]. Consequently, water, as a scarce resource and in demand, commands a price. The factors for water pricing are very varied and highly depend on the use of that water. An intrinsic problem for water pricing is its diversity, both in time and space. Particularly, there exists a high and increasing water demand, which presents inelastic stretches at low prices in wet seasons, and elastic stretches at high prices that correspond to drought or more water consuming seasons in several specific areas [RGL04].

In its origin, water prices are very disperse and highly depend on the basin, its placement and type of water (surface or ground). They may range from 0.1-0.4 euros/m^3 (0.15 in the average) in normal years and 0.15-0.6 euros/m^3 (0.35 in the average) in drought years for surface water [Cal06]. On the other hand, ground water from aquifers has usually a higher price than surface water, e.g. 0.12-0.75 euros/m^3 and are more zone-dependent. Transportation costs may range from 0.10-0.12 euros/m^3 but, obviously, they are very variable depending on the type of required infrastructure, the distance and the height to be covered, which also requires additional energy consumption, such as electricity. Fortunately for irrigators, it is usual that in drought years this latter cost is partly defrayed by the government.

In the destination, water pricing is becoming more widespread, with the dual aim of expanding supply and encouraging a more responsible use. As the most water consuming agent is agriculture, it is there where there exists a higher variability. In agriculture, the water cost is directly related to the cost for producing crops. Clearly, the pricing highly depends on the number of harvests per year and the type of crop, ranging for instance from saffron that requires 1,000 m^3/ha to alfalfa that requires 7,600. Although these values keep more or less constant, they may suffer small variations from year to year and from one area to another, which makes the factors for water pricing more complex.

One additional area of water policy that has become increasingly subject to pricing principles is that of public human (and reduced-consumption industries) water supply, together with wastewater services (sewerage and sewage). Efficient and effective water pricing systems provide incentives for efficient water use and for water quality protec-

tion. They also generate funds for necessary infrastructure development and expansion, and provide a good basis for ensuring that water services can be provided to all citizens at an affordable price. The metering of water consumption is a prerequisite for the application of efficient water pricing policies. About two-thirds of OECD (Organization for Economic Cooperation and Development) member countries already meter more than 90% of single-family houses, although universal metering remains a controversial issue in some contexts, where '*the more you use, the more you pay*'-idea is not fully implemented (e.g. in many places metering tends to be for water supplies entering the building, rather than for individual apartments) [Jon]. Again, this makes the factors for water pricing more difficult.

Overall, industrial water consumption levels are actually not a very good proxy for industrial sewerage and sewage disposal costs, which also have an important impact in the final water pricing, as discharges vary so much from industry to industry. Hence the trend in OECD countries towards separating (i) industrial water use charges from (ii) wastewater charges.

Finally, European countries are working towards more complete recovery of infrastructure and operating costs from users, under the application of the European water framework directive: charge final users with the real cost of infrastructure and environmental impact, which seems to be a more natural way to establish the real water price.

3.4.4 Market entrance conditions

The user has to be a water-right holder, willing to exchange water-rights by means of transfer agreements, and/or interested to be informed on the different water-right agreements executed in mWater.

3.4.5 Normative framework

The NHP plus the different market norms associated with the activities of Section 3.5.

3.5 Activities in the Market scenario

In this section we describe the different activities that are required for the market scenario. Each activity is described including the goals, the playing roles, roles' executing conditions, and the activity regulating norms.

- **Admission and Registration of Water Users**. This activity includes the different steps for registering water users in mWater.
  - Activity Goals: Register Water User.

  - Playing Roles: Market Facilitator, Basin Regulating Authority, Water User.
  - Execution Conditions: The Water User is interested in participating in water-right transfer agreements and/or wants to be informed of water-right agreements executed in mWater.
  - Norms: The Water User has to be a water right-holder of the basin.

- **Registration of a Buyer**. This activity includes the interaction required for registering a water-right buyer.
  - Activity Goals: Register a Buyer.
  - Playing Roles: Market Facilitator, Water User, Buyer.
  - Execution Conditions: The water user is seeking for purchasing water-rights.
  - Norms: The Buyer has no pending sanctions.

- **Registration of a Seller**. This activity includes the interaction required for registering a water-right seller.
  - Activity Goals: Register a Seller.
  - Playing Roles: Market Facilitator, Water User, Seller.
  - Execution Conditions: The water user is interested in selling its water-right in the future.
  - Norms: The Seller has no pending sanctions.

- **Group Formation**
  - Activity Goals: Create a group of water users that want to sell or buy water-rights as a single entity.
  - Playing Roles: Market Facilitator, Water User.
  - Execution Conditions: The water users are interested in configuring a seller or buyer group association.
  - Norms: No water user of the group has pending sanctions.

- **Publish Water-Right Offer**
  - Activity Goals: Make public a water-right offer.
  - Playing Roles: Market Facilitator, Seller.
  - Execution Conditions: The seller has a water-right he/she is not willing to use, and he/she wants to sell it at a given price.

  - Norms: The seller owns the water-right he/she is offering. The time period in the offer is for the future, and does not exceed the remaining time for the concession expiration. The time period of the water-right offer is not already sold. The seller has no pending sanctions.

- **Publish Water-Right Demand**

  - Activity Goals: Make public a water-right demand
  - Playing Roles: Market Facilitator, Buyer.
  - Execution Conditions: The buyer wants to purchase water-rights for a given time period, and at a given price.
  - Norms: The buyer has no pending sanctions. The time period in the demand is for the future.

- **Withdraw Water-Right Offer**

  - Activity Goals: Remove a water-right offer.
  - Playing Roles: Market Facilitator, Seller.
  - Execution Conditions: The seller wants to withdraw a water-right offer already published by him/her.
  - Norms: The water-right offer was published by the seller who wants to withdraw it. There is no water-right agreement related with the water-right that is pending for authorization.

- **Withdraw Water-Right Demand**

  - Activity Goals: Delete a water-right demand.
  - Playing Roles: Market Facilitator, Buyer.
  - Execution Conditions: The buyer wants to withdraw a water-right demand already published by him/her.
  - Norms: The water-right demand was published by the buyer who wants to withdraw it. There is no water-right transfer agreement related with the water-right that is pending for authorization.

- **Query Water-Right offers**

  - Activity Goals: Seek information on current water-right offers.
  - Playing Roles: Market Facilitator, Water User
  - Execution Conditions: The water user wants to know which are the water-right offers that are currently published.

  - Norms: No norm applies.

- **Query Water-Right demands**
  - Activity Goals: Seek information on current water-right demands.
  - Playing Roles: Market Facilitator, Water User
  - Execution Conditions: The water user wants to know which are the water-right demands that are currently published.
  - Norms: No norm applies.

- **Negotiate Water-Right transfer agreement**
  - Activity Goals: Negotiate the terms and conditions of a water-right transfer agreement. Sign a water-right transfer contract.
  - Playing Roles: Market Facilitator, Buyer, Seller, Third Party.
  - Execution Conditions: The seller wants to sell a water-right and the buyer wants to purchase it (and possibly there is a third party affected by the transfer).
  - Norms: The buyer and seller have no pending sanctions. The seller owns the water-right that is being negotiated. There is no water-right transfer agreement related with the negotiating water-right that is pending for authorization. The time period of the water-right offer is not already sold.

- **Registration and Publication of Water-Right transfer agreement**
  - Activity Goals: Make public a water-right transfer agreement. Register the water-right transfer agreement in order to get it authorized.
  - Playing Roles: Market Facilitator, Buyer, Seller, Third Party.
  - Execution Conditions: The buyer and seller (and possibly a third party) have a signed water-right transfer agreement and want to get the authorization from the Basin Administration to execute it.
  - Norms: The water-right agreement is endorsed by the buyer and seller (and possibly by a third party).

- **Query Water-Right transfer agreements**
  - Activity Goals: Seek information on current water-right agreements that are in publishing status.
  - Playing Roles: Market Facilitator, Water User
  - Execution Conditions: The water user wants to know which are the water-right agreements that are currently published.

  - Norms: No norm applies.

- **Allegation (grievance) against a Water-Right transfer agreement**
  - Activity Goals: Denounce a water-right transfer agreement.
  - Playing Roles: Market Facilitator, Water User, Third Party
  - Execution Conditions: A water user finds out that he/she is being affected by a water-right transfer agreement and wants to denounce it.
  - Norms: The denouncement must be presented on time.

- **Authorization of Water-Right transfer agreement**
  - Activity Goals: Authorize a water-right transfer agreement.
  - Playing Roles: Market Facilitator, Basin regulating authority.
  - Execution Conditions: A water-right transfer agreement is published and is pending for authorization.
  - Norms: The water-right transfer agreement conforms to the NHP normative regulation on water-right transfer. There is no allegation against the water-right transfer agreement.

- **Execution of Water-Right transfer agreement**
  - Activity Goals: The buyer gets the water-right transferred from the seller. The seller receives its pecuniary compensation from the buyer. If there is a Third Party, he/she also receive the agreed compensation.
  - Playing Roles: Buyer, Seller, and possibly Third Party.
  - Execution Conditions: The water-right transfer agreement is authorized and the parties want to execute it.
  - Norms: The water-right transfer agreement was previously authorized by the Basin Administration. There is no allegation against the water-right transfer agreement.

- **Hearing of water dispute**
  - Activity Goals: Judge a water dispute.
  - Playing Roles: Water User, Jury.
  - Execution Conditions: A water user has a water dispute with other water user and denounces it to the Jury.
  - Norms: The allegations presented by the prosecutor against the other water user are any of the followings:

    - Any action or omission that alters or damages the water usage that belongs to any member, as well as the wrong water exploitation.
    - The infraction of any of the rules of the User Assembly, as well as the omission of the duties, and the insubordination to the assembly worker.
    - Any action or omission that is detrimental to the User Assembly or its members, although it is not included in its statutes.

- **Sanctioning offenses in a water-right transfer agreement**
  - Activity Goals: Sanction offenses in a water-right transfer agreement.
  - Playing Roles: Water User, Basin regulating authority, Jury.
  - Execution Conditions: There is a sanction for a water user that needs execution.
  - Norms: The Jury has judged the offense and decided to sanction it.
- **Expel Water user**
  - Activity Goals: Expel water users that do not conform with the basin normative regulation and the market rules.
  - Playing Roles: Market Facilitator, Basin regulating authority, Water user.
  - Execution Conditions: There is an infraction of the market rules and the water user has to be expelled from the market.
  - Norms: several, open norms can be applied here.

3.6 Performance and quality criteria for the market

Deciding when a model for a water market is better than another is an essential goal for evaluating the performance and quality of a market scenario. Clearly, the quality of such a complex model cannot be measured just in terms of one factor and, as commonly agreed in literature [CLM04], water resources planning must combine a multiobjective analysis that comprises multiple criteria based on differing objectives, responsibilities and interests among the stakeholders, groups or institutions involved in the market. The problem here relies on the conflicting nature of these criteria, because minimizing one criterion usually entails maximizing another. In this multiobjective analysis model, the main issues to be considered are:

- Economic development.
- Social welfare.
- Environment preservation.

- Agricultural self-sufficiency.
- Financial feasibility, which includes all costs seen in Section 3.4.3.

The two first issues include maximizing regional economic deployment and minimizing unemployment. Since high water-consuming industries are those that employ many workers, employment is sensitive to water availability in most regions. Social welfare and environment preservation is usually obtained by increasing the amount of available water, its quality and making a better use of the demand for domestic and small industries. From the agricultural perspective, the goal is to maximize food production in order to attain self-sufficiency and nutrition, while also minimizing the cost of such water and its transportation (function of land area, effective rainfall and water supply availability and crop mix). Finally, all these issues can be achieved at a high global cost which is based on industry structure, population, quality standards, existing treatment plants, investment for new treatment plants, and policy for water allocation among agriculture, industry and domestic sectors.

Chapter 4

Design of mWater prototype #1

The *mWater* framework is rooted on traditional practices and regulations for the use and transfer of water rights that are either currently established by the Spanish National Hydrological Plan or are to be part of the forthcoming Basin Hydrological Plans. However, it is somewhat idealized in order to provide a richer sandbox for agreement technologies and a more malleable platform for demand and water use modeling in an hydrographic basin [BGG+09]. The core component of the *mWater* demonstrator is an agent-based virtual market for water usage rights that intends to grasp the components of an electronic market where water rights could be traded with flexibility and under different price-fixing mechanisms. However, in addition to trading proper, the demonstrator also includes those activities that follow trading; namely, the agreement on a contract, the use and misuse of rights and the grievances and corrective actions taken therein. These ancillary activities are particularly prone to conflict albeit regulated through legal and social norms, and therefore a crucial objective in policy-making and a natural environment for agreement technologies.

Our immediate goal is to establish an institutional framework for an on-line market of water rights. In this paper we only sketch the institutional framework that regiments trading and the main ancillary activities. It is institutional in the sense that we make explicit the conventions that determine: i) what actions are valid within the market, ii) what are the conditions these actions must satisfy, and iii) what are their intended effects. For the construction of that framework we follow the IIIA *Electronic Institution* (EI) conceptual model [AEN+05], where an institution is specified through two main blocks: one that deals with ontological components (the *dialogical framework* that specifies ontology, language, roles and information model) and another for deontological components (the *performative structure* that includes, both, interaction models and procedural prescriptions, as well as *rules of behavior* for commitment-making conventions). For the actual specification and implementation of *mWater* we use the EIDE platform.[1] The following

[1]EIDE is a development environment for Electronic Institutions, built at the IIIA, http://e-institutor.iiia.csic.es/eide/pub. It is composed of a set of software tools that support all the stages of an

subsections describe the main components of the market institution. We will also use the method published in [GB04a, GB06, GV09] in order to discover the computational entities of mWater and their attributes.

4.1 Assumptions and definitions

We take a water right to be defined with four components: the type of use allowed by the right, the location where the right is valid, the amount of water that may be drawn and the time during which the right is valid. We assume that:

- Rights are owned by individuals or by entities with a legal identity (firms, associations or municipalities)
- There is a non-electronic market where an individual may acquire a water right that is potentially tradable, and where an individual may either unburden himself or become disentitled of a tradable right that might thereof disappear, be transformed into new rights or become latent.
- A right becomes tradable only when a rightful owner registers the actual right and its legal entitlement to it in the market.
- Only rightful owners, or properly entitled agents, may participate in the market.
- Software agents may be properly entitled to trade and their owners are liable for their acts.
- A basin is representable as a directed graph whose nodes are places where water may be extracted and edges indicate that one node receives water from another.
- A water right may be split into smaller water rights as long as the parts are rights in themselves and are consistent with the original right.
- A water right may be used, and transferred, for any water use that has a priority higher than the original.
- A water right may be transferred for a fixed time period after which it returns to its original owner.
- A water right for a given location and use may be shared by two right owners who split the volume of water used.

Electronic Institution (EI) engineering, namely: 1) ISLANDER, a tool for EI specification; 2) aBUILDER, a tool to support the automatic generation of agent (code) skeletons from ISLANDER specifications of an EI; 3) the AMELI middleware that handles the enactment of the institution; and 4) SIMDEI, a testing and monitoring tool.

- A water right may be traded face to face, under a closed bid auction or through a conventional double auction.
- Rights may be put for sale or called for purchase with a deadline for the transaction to take place.
- Once a right has been traded, the operation is subject to challenge for a fix period of time.

4.2 The *mWater proposal*

Basin Authorities. Spain comprises nine Basin Authorities (Organismos de Cuenca) attached to the Ministry of the Environment and Rural and Marine Affairs[2]. Each basin authority plays an essential role in hydrologic planning, management of water resources (uses and private rights), quality control and the design of new infrastructure. They would affect directly a water rights market through the issuance of new rights, the suspension and the annulment of existing rights and the possibility of modifying water use conditions. They are also involved in the formalization and publication of transfer contracts and in settling disputes over the signing of a transfer contract or its enactment. We would like to include these roles in the *mWater* functionalities.

Basin Resources. The territorial component for water right exchanges in a basin is generally represented as geographical regions (with some orographic components like elevation, soil types, vegetation and land use) with a network of rivers, a number of basin-specific water sources and fountainheads, transport infrastructure like dams, canals and pumping stations, and administrative jurisdiction. We will start with a simplification of the territorial component by abstracting the system as a directed weighted graph. Each node representing a location where water may be used and the volume of water that is available in that location (and therefore subject to entitlement and transfer of a water right), links representing transport conditions (capacity, cost, ownership) between nodes.

Decomposable water rights. Although current legislation already states some components of a water right, we will introduce an enriched definition that is compatible with the current one but adds flexibility to the trading of rights. Thus we define a right through the place where water is drawned, the basin district where the source is located, the maximum amount of authorized extraction, the type of use allowed for the water and the period during which the right is valid. Additionally we will allow to split water rights into subrights and also to assemble new (single) rights from existing ones, regulating how these operations may be achieved in a coherent way.

[2] http://www.marm.es

Multiple trading modalities. Currently there is no standard trading mechanism for water rights. Therefore, we will take inspiration from the legislation on water banks and include many price-fixing mechanism, from standard double auction exchanges to facilitated many-to-many negotiation.

Creation, suspension and annulment of rights. So that the market may be expanded or contracted by basin and state authorities both in a temporary or exceptional situation, or in a more permanent or generic way. We want to enable the possibility of acquiring grants without prior property of land and the possibility of upgrading or downgrading water use requirements through negotiation among users and with authorities.

Full right transfer cycle. We want to do justice to the complexity of the transferring of water rights and will include creation, negotiation of agreements, signing of contracts, contract enactment, contract termination and grievances.

ODR-prone features. In particular we want to facilitate the use of agent-based resources to deal with most of the activities associated with the market and, in particular, we want to facilitate contract negotiation and fulfillment through appropriate on-line dispute resolution devices. Similarly for grievances from affected third parties.

4.3 AN ISLANDER specification

4.3.1 Dialogical Framework

Roles

There are three main **roles** in the virtual water market. Firstly, a *Guest* role is a user that wants to enter the *mWater*. The *Guest* may be specialized into a *Water User*, a water right-holder of the basin, and furthermore as a *Buyer*, *Seller* and as (an affected) *Third party*. Secondly, there are two governing roles involved in grievances and contract validation processes: *Basin authority* and *Referee*. Thirdly, the *Market Facilitator* role represents those institutional agents who run standard trading activities, for example set up a trading table or mediate in a face-to-face negotiation.

Illocutory particles

Accept. The sender communicates the receiver the requested action is going to be carried out. This is particularly useful in the accreditation process of the water right.

Inform. The sender informs the receiver the communicated message is truthful.

Query. The sender asks the receiver for some particular information.

Refuse. The sender communicates the receiver the requested action is not going to be carried out. This is particularly useful in the accreditation process of the water right.

Request. The sender requests the receiver to carry out a particular action. The content of the message comprises a description of the action to be done.

Functions

Next, we define the functions to be used in the scenes of our framework. We include a description of each function and the scene/s where it is used in brackets.

auctionSuccessful(): all the members participating in the blind double auction have been matched with another member, thus making an agreement between them, and everyone at the same price, which has converged to the market (real) price. [Blind Double Auction scene]

bid(): a buyer informs the market facilitator (s)he bids for the current price and object in an auction. [Dutch & English Auctions scenes]

close(): the current scene is terminated. [Nearly all the scenes]

contractEnactment(Contract c): the basin authority enacts a contract that will be necessarily signed by both the seller and the buyer. [Contract Enactment scene]

dutchInfo(float price, float minPrice, time waitTime): the seller provides the market facilitator the parameters required to start a Dutch auction: initial price, minimum price and wait time between rounds. [Dutch Auction scene]

endow(waterRight w): a water user requests the endowment of a free water right. [Entitlement scene]

englishInfo(float price, time timeout): the seller provides the market facilitator the parameters required to start an English Auction: the initial price and the length of the timeout, for declaring the auction end. [English Auction scene]

finished(): the sender notifies that has finished exposing a list of arguments. [Hearing Dispute scene]

grievId(integer id): the market facilitator informs an agent about the performative structure's identifier of the grievance process where that agent must go. [Ongoing Agreements scene]

grievStart(agent a): a plaintiff requests the market facilitator to start a new grievance process, and notify the given agent that (s)he must attend the process as an affected party. [Ongoing Agreements scene]

inviteToRoom(integer id, string parameters): the market facilitator invites one or several agents to join an open negotiation process, with a predefined parameters, but only when the receivers meet the invitation criteria. [Recruiting scene]

juryCall(integer id): the jury is called by the market facilitator to mediate in a dispute. The parameter is the dispute identifier. [Jury Room scene]

*listAgreements(Agreement *list)*: the market facilitator returns a list of the current agreements active in the market to the water user who requests such information, so the user may determine if (s)he is involved in any of them, and then initiate a grievance procedure. [Ongoing Agreements scene]

*listRights(waterRight *list)*: the market facilitator returns a list of the currently available water rights of the market, so a new user may request an endowment of any of them. [Entitlement scene]

*listTrades(string *list)*: the market facilitator responds to a request made by a water user who wants to be informed of the currently open negotiations. This call is preceded by a *queryTrades()* invocation. [Open Trades scene]

matchDetails(agreement agr): the negotiation table manager informs the agent about the agreement that was just created in the double auction, so the agent may finally know who is the other agent (s)he will trade the water with. [Blind Double Auction scene]

matched(): the negotiation table manager informs a participant in the blind double auction that his/her bid has been matched with another agent bid. Thus, the agent will not need to make a counteroffer. [Blind Double Auction scene]

newArgument(string arg): an agent provides new information on a dispute where (s)he is participating (wether as a plaintiff or an affected). [Grievance Protocol & Hearing Dispute scenes]

newSituation(string situation): the market facilitator informs all the water users in the market about an anomalous situation that affects the regular behavior of the market. [Critical Situations scene]

offer(float price): the market facilitator broadcasts the current offer to the present traders of the auction. [Dutch & English Auction scenes] —The water user participating in the Blind Double Auction makes a new offer in this round. [Blind Double Auction scene]

publishVeredict(string verdict): a member of the jury, speaking in representation of the all the jury, pronounces the final decision about the current dispute after hearing both parts arguments. [Hearing Dispute scene]

queryAgreements(): a water user requests to the market facilitator a list of the current active agreements. A listAgreements call will answer this demand. [Ongoing Agreements scene]

queryRights(): a water user requests to the market facilitator a list of the currently available water rights of the market. A listRights call will reply this demand. [Entitlement scene]

queryTrades(): a water user requests the market facilitator a list of the currently open negotiations in the market. This call is followed by listTrades. [Open Trades scene]

regRight(waterRight w): a water user requests to the basin authority the registration of a new water right in the market. [Entitlement scene] —A water user proves his/her intention to trade with the specified water right. [Accreditation scene]

restart(): ff after several counteroffers all the participants of the blind double auction are not matched, the round is restarted with this call and all the members must make a new offer. [Blind Double Auction scene]

sanction(string sctn): a member of the jury communicates the affected agent the sanction to be applied for a given dispute. The agent will then have to accept the sanction. [Sanctioning Offenses scene]

start(): the current scene is initiated. [Nearly all scenes]

startAuction(item i, float price, time waitTime): the market facilitator broadcasts the properties of the auction that just started, providing the item, its starting price and the maximum time between rounds. [Dutch & English Auctions scenes]

startDoubleAuction(item i, date d): the negotiation table manager declares the current auction started, and informs the agents of its parameters: the item that is going to be traded, and the timeout. [Blind Double Auction scene]

tableId(integer id): the market facilitator responds a request to start a new negotiation table with this call, providing the identifier of the newly created table. [Registration & Registering scenes]

*tableReqEntry(string *list)*: a buyer or a seller requests to enter a negotiation table. The negotiation table manager will accept or decline this request, and in the last case, the manager will provide a list of reasons. [Registration scene]

tableStart(string p): a water user requests the creation of a new negotiation table that fits the properties provided. The market facilitator will invite the water users that fulfill the recruiting criteria. [Recruiting scene]

*v_fail(string issue, string *list)*: the market facilitator notifies a water user of a failure of the prerequisites on a given issue and, if necessary, will provide a list of reasons to do so. [Validation, Agreement Validation & Annulment scenes]

v_ok(string issue): the market facilitator accepts or confirms an issue to a water user. [Validation, Agreement Validation & Annulment scenes]

validateAgr(agreement a): the involved parties in the agreement (buyer and seller) request the basin authority to validate the provided agreement. [Validation, Agreement Validation & Annulment scenes]

Ontological components

The following entities are the basis for the domain ontology:

Basin. A basin is a directed graph $\Lambda = \langle N, E \rangle$, where $N = \{n_i : 1 \leq i \leq m\}$ is a set of places where water may be extracted, $E = \{\langle n_i, n_j \rangle : n_i, n_j \in N \wedge i \neq j\}$, is a set of edges, where a tuple $\langle n_i, n_j \rangle \in E$ indicates that node n_j receives water from n_i by means of a transportation resource (river or canal). Λ can be unconnected, whenever a node is an isolated well or there are unconnected clusters in Λ.

Water-right. A water-right is a tuple $\omega = \langle \lambda, u, v, t \rangle$, where λ (subgraph of Λ) is the basin locations where the water-right can be executed (at least one node in λ must be a water source node); u is the usage allowed; v represents the maximum quantity of water allowed to be extracted there; and t is the time interval during which the water-right may be executed.

Water-right bid. A water-right bid is defined as the tuple $\beta = \langle o, \omega, t, t_\beta \rangle$, where the bid-type o can take a Put label to represent a bid to sell, or a $Call$ for a bid to buy; ω is the water-right associated with a bid t is the time interval during which the water-right would be used; t_β is the deadline of the bid.

Agreement. An agreement is a tuple $\alpha = \langle s, b, \omega', p, d, st \rangle$, where s is the seller of the right; b is the buyer; ω' is the new water-right derived from the agreement negotiation (this water-right will be granted to the buyer by means of a contract); p is the agreed economic compensation; d is the agreement date;
$st \in \{Public, Contested, Authorized, Suspended\}$ represents the current stage of its life-cycle[3].

[3]Possible stages are: *Public*, when it is registered by the buyer and seller and it is waiting for the Basin Authorities endorsement; *Contested*, when it is contested by a third party who claims his rights are affected by the agreement; *Authorized*, by the Basin Authorities; *Suspended*, by the Basin Authorities due to an exceptional drought situation or a misuse of the transfer; *Valid*, the water-right transfer is being executed; *Done* the water-right transfer was executed and the time-period has expired.

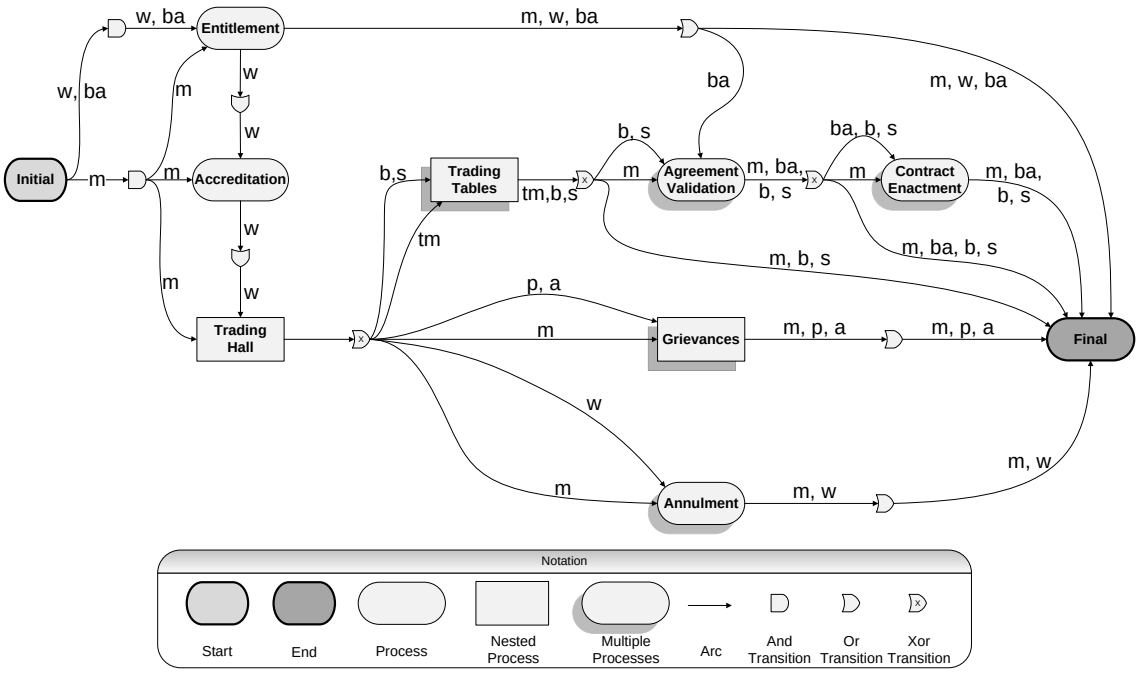

Figure 4.1: mWater performative structure

Contract. A contract is the signed agreement among the contracting parties. It is defined by the tuple $\kappa = \langle A, K, U, d, O, C \rangle$, where A is the set of related agreements (a set of multiple water transfer agreements may be signed in a single contract); K is the set of related sub-contracts, for example transportation resource contracts (if there is no related sub-contracts it is an empty set); U is the set of users that sign the contract; d is the agreement date; O is the set of observation commitments to execute the contract; C is the set of conditions for conflict resolution.

4.3.2 Performative Structure

In this section the different performative structures of *mWater* will be detailed.

mWPS

mWater is a nested performative structure. The top one, mWaterPS, (Fig. 4.1) describes the overall market. It includes three other performative structures, TradingHallPS, TradingTablesPS and GrievancesPS that, to provide more design flexibility, expand the *TradingHall*, *TradingTables* and *Grievances* processes (nodes) of wWaterPS, respectively.

Let's first look into mWaterPS. Recall that only bona fide right-holders may trade water rights in the market. So, in order to start the market there needs to be a process through which an individual proves to the market that he is the rightful holder of a given

water right and thus entitled to trade it. How does one become a rightful owner of a right? How does a rightful owner of a right enters the market? These two processes are dealt with in the *entitlement* and the *accreditation* scenes, respectively, discussed below. In both cases, there must be some legal document that proves that a potential trader is in fact entitled to trade that right. This process is carried out in the *entitlement* scene of mWater whose goals are:

1. To enable someone to trade a right that it proves to be legally entitled to trade.
2. To endow someone with the entitlement to trade a particular right (because of newly created, annulled or suspended rights become tradeable).

The *accreditation* scene, in turn, makes it possible to "jump start" a market (different basins may have their own mWater markets but certain preconditions —like a minimum number of rights and accredited right-holders, special emergency or drought situations, etc.— need to be fulfilled before the market becomes active). Once a market is open, this scene allows legally entitled right-holders to enter and trade by registering their rights and individual data for management and enforcement purposes. Staff have to validate admission conventions and right-holder variables are given default variables.

TradingHall

Actual trading starts in this complex performative structure (see Fig. 4.2). Users and trading staff can initiate most trading and ancillary operations from the *Recruiting* scene: open, request trading parties and enter a trading table; query about different agreements and initiate a grievance procedure from the *Ongoing Agreements* scene or, in the same scene, get informed about a dispute in which the water user is affected. Right-holders become aware of the market activity in the *Open Trades* scene, and get informed about anomalous situations, for example severe drought situations, in the *Critical Situations* scene. Members of the Jury may also be required to mediate in a dispute at the *Jury Room* scene.

Technically speaking, all these scenes are "stay-and-go" scenes: while the users are inside the market, they have to *stay* permanently in these scenes but they may also *go* (as *alteroids*) to trading table scenes and contract enactment scenes where they are involved: these scenes where user alteroids become involved are created (as a new *instance* of the corresponding performative structures) when a staff agent has a request from a user, an authority, or because of a pre-established convention (like weekly auctions).

Trading Table

In our *mWater* performative structure (recall Fig. 4.1), a market facilitator can open a new trading table whenever a new auction period starts or whenever a right-holder requests to

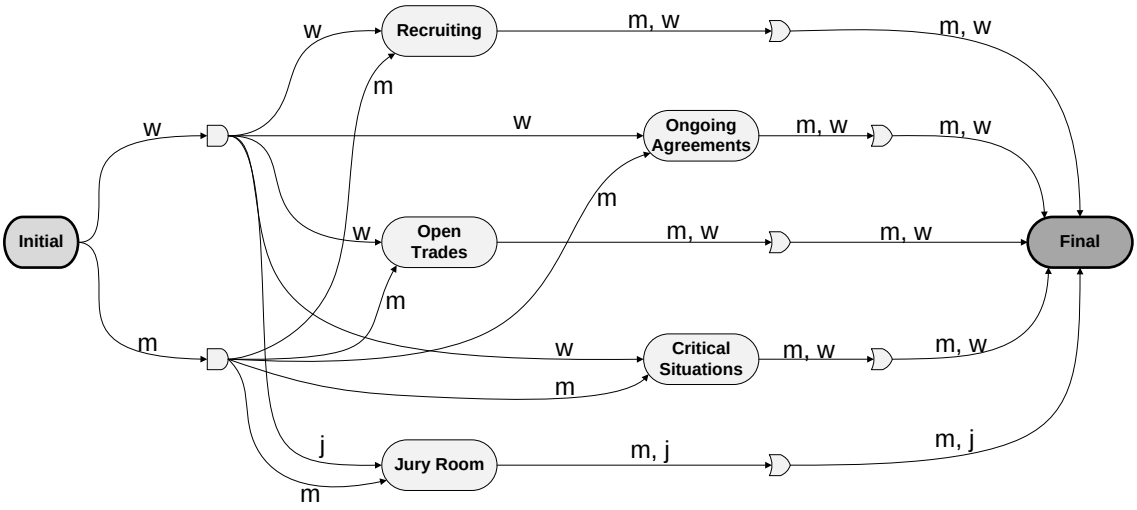

Figure 4.2: *TradingHall* performative structure.

trade a right outside the auction hall. In such a case, a right-holder chooses a negotiation protocol from a set of available ones (e.g., face to face negotiation, closed bids, standard double auction exchange or any others that are agreed upon). Consequently, in order to accommodate different trading mechanisms, we assemble the *TradingTable* performative structure as a list of different scenes, each corresponding to a valid trading mechanism or negotiation protocol. Each instance of a *Trading Table* scene is managed by a *Negotiation Table Manager*, tm, who knows the structure, specific data and management protocol of the given negotiation protocol. Among other negotiation mechanisms, we have included face-to-face, Dutch auction, English auction, standard double auction and blind double auction with mediator negotiation. Nevertheless, new negotiation protocols may be easily added providing that the new protocol definition complies with the generic structure.

Every generic negotiation table is defined as a three-scene performative structure (see Fig. 4.3). The first scene is *Registration*, in which the tm applies a filtering process to assure that only valid water users can enter a given trading table (recall situations when a private trading table is executing or only a sub-group of water users that fulfill a set of constraints may participate in the table). The specific filtering process will depend on the given negotiation protocol and possibly on domain specific features. The second scene is the negotiation protocol itself, in which the set of steps of the given protocol are specified. Finally, in the last scene, *Validation*, a set of closing activities are executed, for example registering the final deals, stating the following steps for the agreement settlement, verifying that the party that leaves the table satisfies the exit norms of the trading table, etc.

Notice in mWaterPS that ”Trading Tables” is a ”new” transition because staff will open a new trading table whenever a new auction period starts and whenever a right-holder requests to trade a right outside the auction hall.

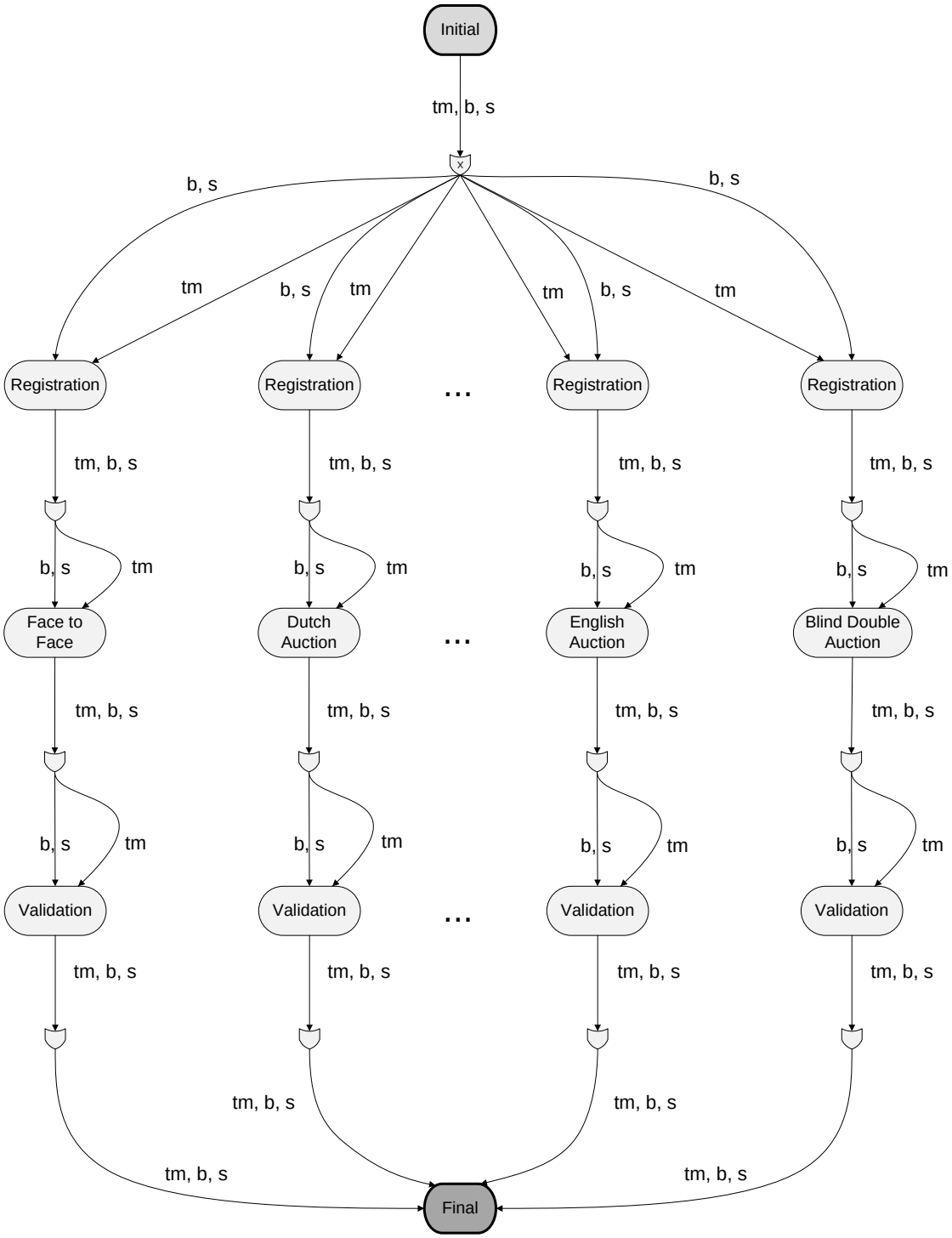

Figure 4.3: Performative structure for different trading procedures: *TradingTables*.

Grievances

Once an agreement is active, it may be executed by the new right-holder and, consequently, other right-holders and some external stakeholders may initiate a grievance pro-

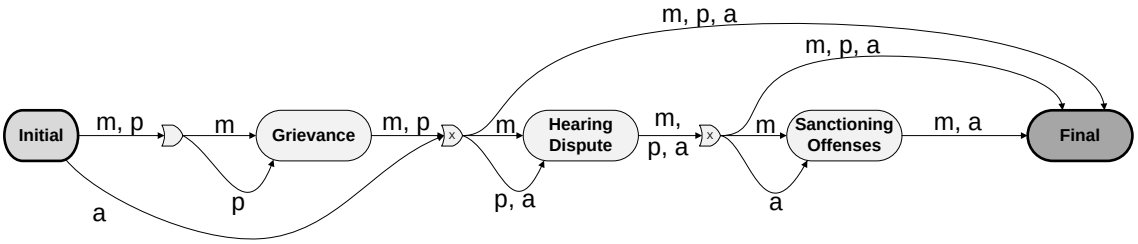

Figure 4.4: Performative structure of the process to manage a grievance procedure.

cedure (see Fig. 4.4) that may overturn or modify the transfer agreement. Even if there are no grievances that modify a contract, parties might not fulfill the contract properly and there might be some contract reparation actions. If things proceed smoothly, the right subsists until maturity.

Conflicts are managed in a three step process. In the first step, any water user may initiate a grievance process in which (s)he presents claims and arguments. The complaints are evaluated by the market authority and if deemed relevant may then proceed to the second step, where the *mWater* staff informs the affected parties of the dispute in order to execute their rights to appeal. A jury and/or a referee hears the dispute among the parties and determines the outcome. Finally, in the third step, the Jury issues the sentence informing the parties and imposing sanction to transgressors, if any.

4.3.3 mWater scenes

Entitlement

Only bona fide right-holders may trade water rights in the market and there are only two ways of becoming the owner of a right. The former happens when an existing right is legally acquired from its previous owner outside of mWater (through inheritance or pecuniary compensation for example). The latter happens when a new right is created by the mWater authorities and an eligible holder claims it and gets it granted. This scene gives access to the market to new right holders who prove they are entitled to trade. It is also used to bootstrap the market.

In the Entitlement scene (Figure 4.5), apart from the initial and final states (W1 and W6, respectively), we can find the following:

- W2: the main state of the scene. From here, water users may send requests to the market facilitator, as well as enter or leave the process.
- W3: a water user requests a list of the tradeable water rights in the market, and he is waiting for the market facilitator to respond to the query.

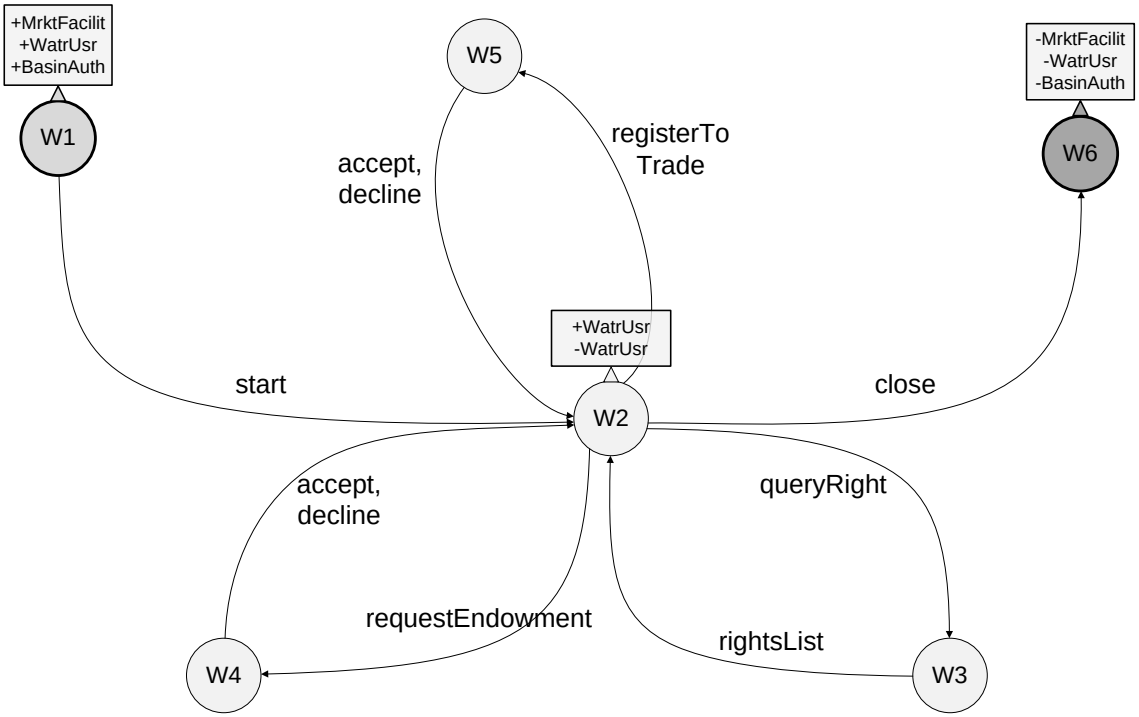

Figure 4.5: Scene protocol to become the owner of a right: Entitlement

- W4: in this case, a water user has requested to be endowed with a tradeable water right.
- W5: this state is the result of a water user requesting to register a new water right in the market.

The allowed messages to flow among the states are the following:

- W1 - W2: inform (?m MrktFacilit) (all all) (start)
- W2 - W3: request (?w WatrUsr) (!m MrktFacilit) (queryRights)
- W3 - W2: inform (!m MrktFacilit) (!w WatrUsr) (listRights ?list)
- W2 - W4: request (?w WatrUsr) (?ba BasinAuth) (endow ?right)
- W4 - W2: refuse (!ba BasinAuth) (!w WatrUsr) (endow !right)
- W4 - W2: accept (!ba BasinAuth) (!w WatrUsr) (endow !right)
- W2 - W5: request (?w WatrUsr) (!ba BasinAuth) (regRight ?right)
- W5 - W2: refuse (!ba BasinAuth) (!w WatrUsr) (regRight !right)

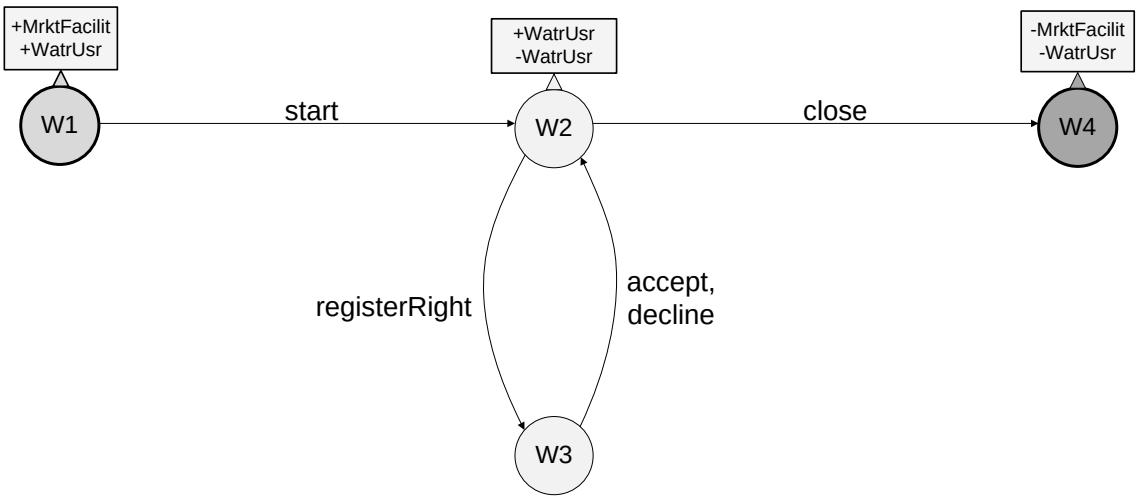

Figure 4.6: Scene protocol to prove the intention to trade: Accreditation

- W5 - W2: accept (!ba BasinAuth) (!w WatrUsr) (regRight !right)
- W2 - W6: inform (!m MrktFacilit) (all all) (close)

Accreditation

This scene allows legally entitled right-holders to enter the market and trade by registering their rights and individual data for management and enforcement purposes. Staff have to validate admission conventions and right-holder variables are given default values. When a right suspension is overridden or an agreement is void, rightful owners need to register again.

In the Accreditation scene (Figure 4.6), apart from the initial and final states (W1 and W4, respectively), we can find the following:

- W2: the main state of the scene. From here, water users may send requests to the market facilitator, as well as enter or leave the process.
- W3: a water user has requested to introduce one of his water rights into the market, thus declaring its intention to trade it.

The allowed messages to flow among the states are the following:

- W1 - W2: inform(?m MrktFacilit) (all WatrUsr) (start)
- W2 - W3: request(?w WatrUsr) (!m MrktFacilit) (regRight ?right)
- W3 - W2: refuse (!m MrktFacilit) (!w WatrUsr) (regRight !right)

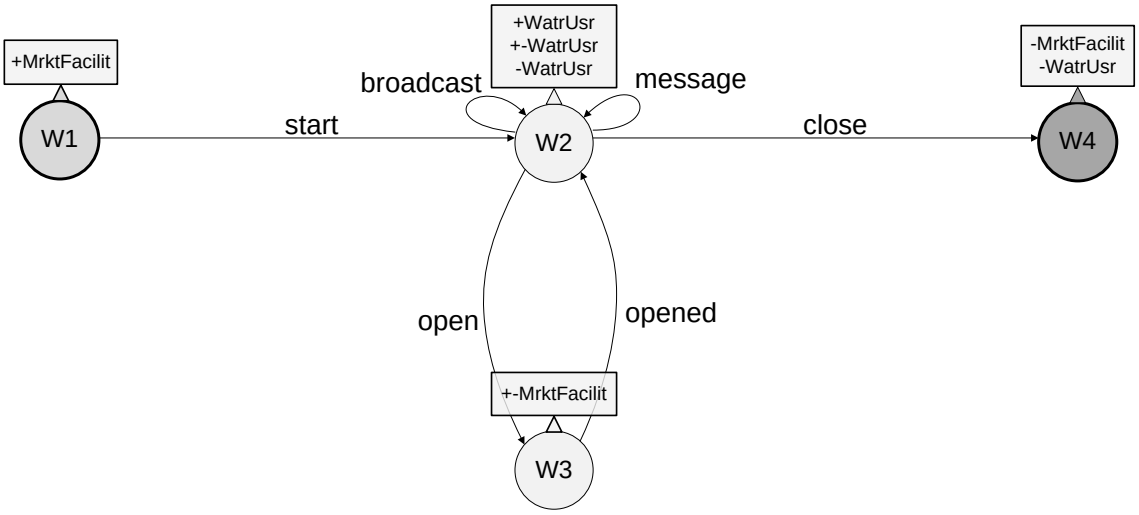

Figure 4.7: Scene protocol to create and be notified of negotiation tables: *Recruiting*

- W3 - W2: accept (!m MrktFacilit) (!w WatrUsr) (regRight !right)
- W2 - W4: inform (!m MrktFacilit) (all all) (close)

Recruiting

As well as in Entitlement, there will be just one Recruiting scene for all the Electronic Institution. Users may request the market facilitator a new negotiation table, as well as receive invitations to other tables created by other users or by the market facilitator itself.

In the Recruiting scene (Figure 4.7), apart from the initial and final states (W1 and W4, respectively), we can find the following:

- W2: the main state of the scene. Water users may request new negotiation tables, and may be notified from new tables that may interest them. They may as well enter or leave the scene.
- W3: the current state will be W3 after a water user requests a new negotiation table, and waits for the market facilitator to create it.

The allowed messages to flow among the states are the following:

- W1 - W2: inform(?m MrktFacilit) (all all) (start)
- W2 - W2: inform(!m MrktFacilit) (all all) (inviteToRoom ?id ?info)
- W2 - W2: inform(!m MrktFacilit) (?w WatrUsr) (inviteToRoom ?id ?info)

- W2 - W3: request (?w WatrUsr) (!m MrktFacilit) (tableStart ?properties)
- W3 - W2: inform (!m MrktFacilit) (!w WatrUsr) (tableId !id)
- W2 - W4: inform (!m MrktFacilit) (all all) (close)

Ongoing Agreements

There will be just one Ongoing Agreements scene for all the Electronic Institution. In this scene, a water user may perform two main actions. The first is to be informed of the current active Agreements in the market, so the water user may know if he is affected by any of them. If he is, then he may start a grievance procedure (the second action). A grievance procedure may be as well invoked by different reasons, not just due to agreements.

In the Ongoing Agreements scene (Figure 4.8), apart from the initial and final states (W1 and W5, respectively), we can find the following:

- W2: the main state of the scene. Water users may request a list of active agreements, as well as start a grievance procedure from here.
- W3: a water user has requested the market facilitator a new dispute room. The market facilitator will respond with the identifier of the room.
- W4: after requesting a list of the currently active agreements, a water user waits for the market facilitator to prepare the list.

The allowed messages to flow among the states are the following:

- W1 - W2: inform(?m MrktFacilit) (all all) (start)
- W2 - W2: request (!m MrktFacilit) (?w WatrUsr) (grievId ?id)
- W2 - W3: request(?w WatrUsr) (!m MrktFacilit) (grievStart ?affected)
- W3 - W2: inform(!m MrktFacilit) (!w WatrUsr) (grievId ?id)
- W2 - W4: request(?w WatrUsr) (!m MrktFacilit) (queryAgreements)
- W4 - W2: inform(!m MrktFacilit) (!w WatrUsr) (listAgreements ?list)
- W2 - W4: inform (!m MrktFacilit) (all all) (close)

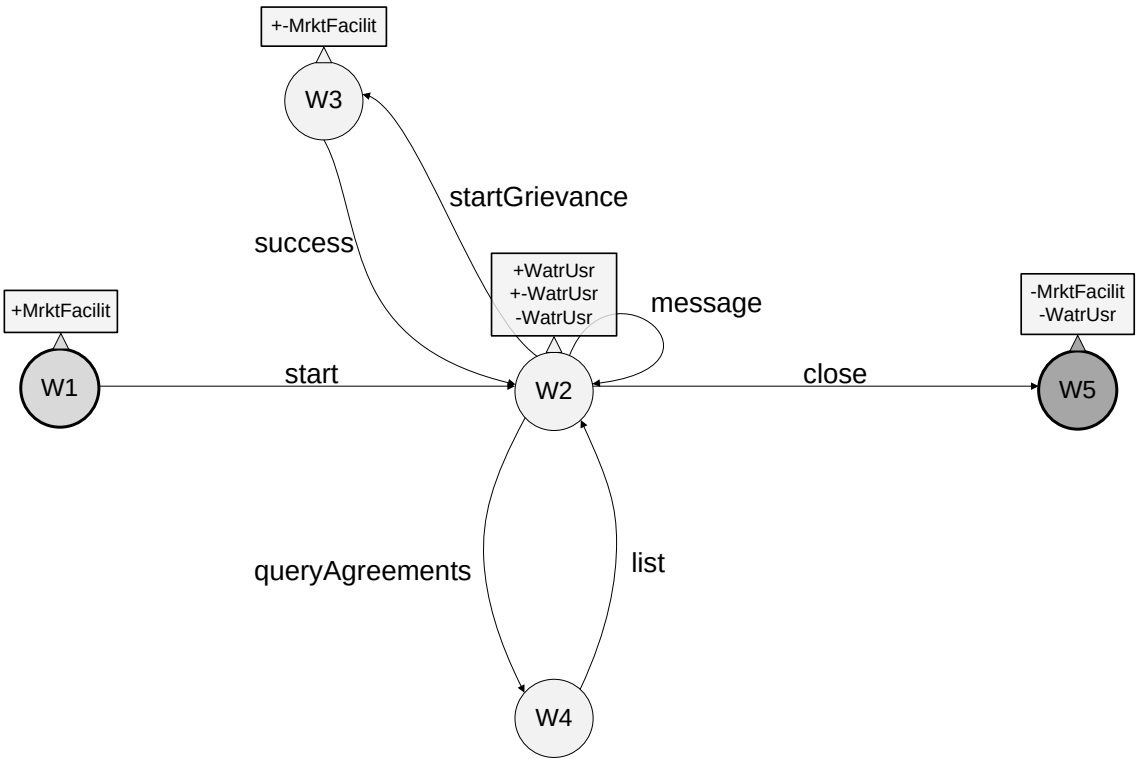

Figure 4.8: Scene protocol to start grievance procedures and be informed of active agreements: *Ongoing Agreements*

Open Trades

Water users will be able to stay updated of the open negotiation tables, where they may join, in this scene.

In the Open Trades scene (Figure 4.9), apart from the initial and final states (W1 and W4, respectively), we can find the following:

- W2: the main state of the scene. Water users may join or leave the scene in this state.
- W3: a water user requested a list of the trading tables where he may join. The market facilitator will respond to the query with a list of the tables.

The allowed messages to flow among the states are the following:

- W1 - W2: inform(?m MrktFacilit) (all all) (start)
- W2 - W3: request(?w WatrUsr) (!m MrktFacilit) (queryTrades)
- W3 - W2: inform (!m MrktFacilit) (?w WatrUsr) (listTrades ?list)

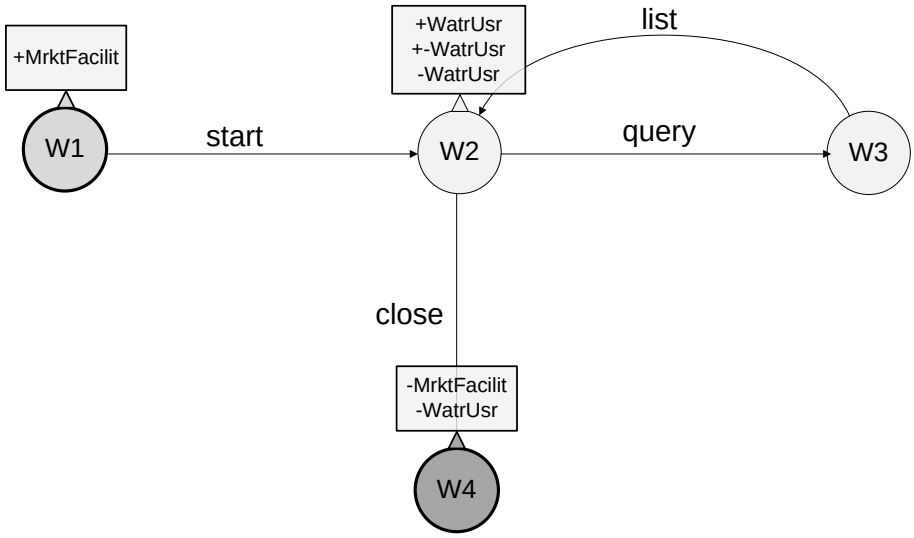

Figure 4.9: Scene protocol to get informed of the open negotiation tables: *Open Trades*

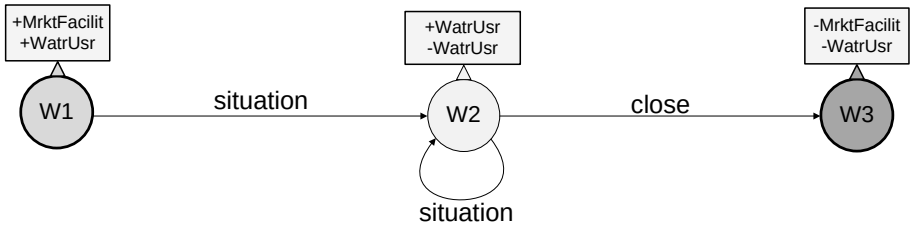

Figure 4.10: Scene protocol to inform the whole market about anomalous situations: *Critical Situations*

- W2 - W4: inform (!m MrktFacilit) (all all) (close)

Critical Situations

The objective of this scene is to have an open communication channel about situations that may change the behavior of the market.

In the Critical Situations scene (Figure 4.10), apart from the initial and final states (W1 and W3, respectively), we can find the following:

- W2: the main state of the scene. Water users may join or leave the scene in this state.

The allowed messages to flow among the states are the following:

- W1 - W2: inform(?m MrktFacilit) (all all) (start)

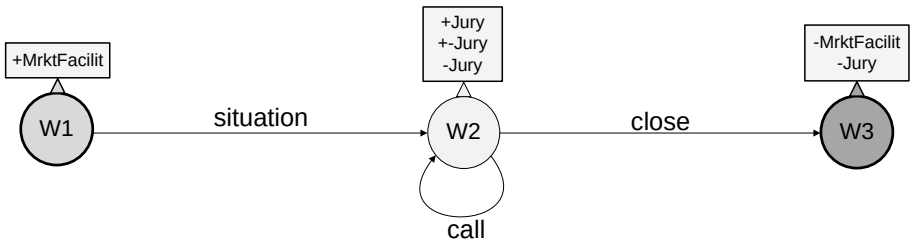

Figure 4.11: Scene protocol to make a call for the jury: *Jury Room*

- W3 - W2: inform (!m MrktFacilit) (all all) (newSituation ?event)
- W2 - W4: inform (!m MrktFacilit) (all all) (close)

Jury Room

The objective of this scene is to be able to communicate with the jury in a private way, and to be able to require its presence in any dispute.

In the Jury Room scene (Figure 4.11), apart from the initial and final states (W1 and W3, respectively), we can find the following:

- W2: the main state of the scene. Jury members may join or leave the scene. The jury will be called from this state if it is required.

The allowed messages to flow among the states are the following:

- W1 - W2: inform(?m MrktFacilit) (all all) (start)
- W2 - W2: inform (!m MrktFacilit) (all Jury) (juryCall ?roomId)
- W2 - W3: inform (!m MrktFacilit) (all all) (close)

Registration

A water user that may show interest in joining a negotiation table has to proof that he fulfills the table selection criteria. This will be done in the Registration scene.

In the Registration scene (Figure 4.12), apart from the initial and final states (W1 and W4, respectively), we can find the following:

- W2: the main state of the scene. Buyers and sellers may join and/or leave in this scene.

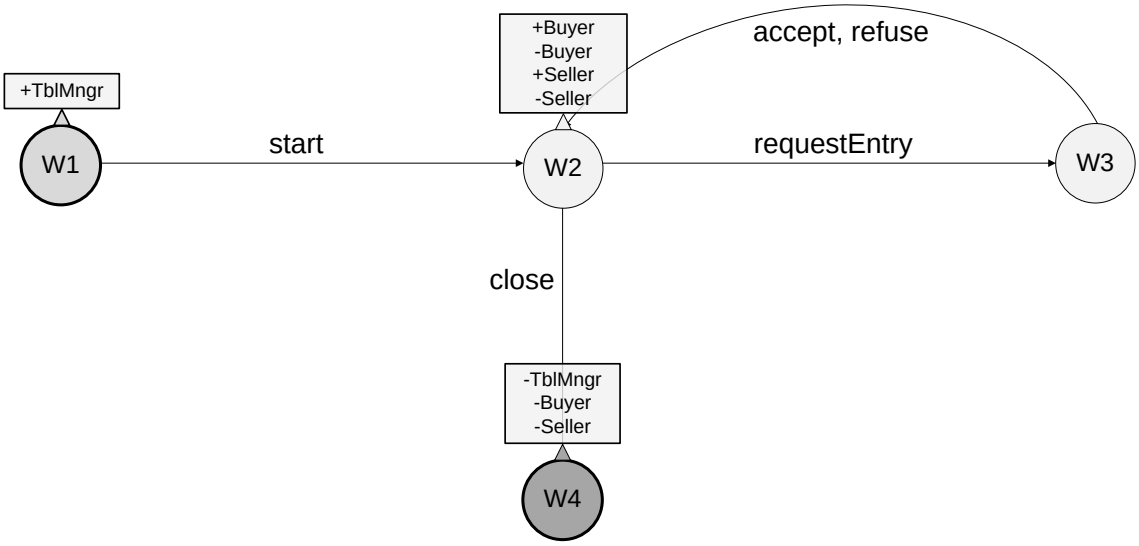

Figure 4.12: Scene protocol to gain access to a negotiation table: *Registration*

- W3: a buyer or seller has requested to join the negotiation table to the table manager. After checking if the requirements are met, the negotiation table manager will accept or decline the request.

The allowed messages to flow among the states are the following:

- W1 - W2: inform(?t TblMngr) (all all) (start)
- W2 - W3: request(?b Buyer) (!t TblMngr) (tableReqEntry ?x)
- W2 - W3: request(?s Seller) (!t TblMngr) (tableReqEntry ?x)
- W3 - W2: accept (!t TblMngr) (?b Buyer) (tableReqEntry ?x)
- W3 - W2: decline (!t TblMngr) (?b Buyer) (tableReqEntry ?x)
- W3 - W2: accept (!t TblMngr) (?s Seller) (tableReqEntry ?x)
- W3 - W2: decline (!t TblMngr) (?s Seller) (tableReqEntry ?x)
- W2 - W4: inform (!t TblMngr) (all all) (close)

Dutch auction

This is one of the possible negotiation protocols that a buyer and a seller may choose to trade water.

In the Dutch auction scene (Figure 4.13), apart from the initial and final states (W1 and W6, respectively), we can find the following:

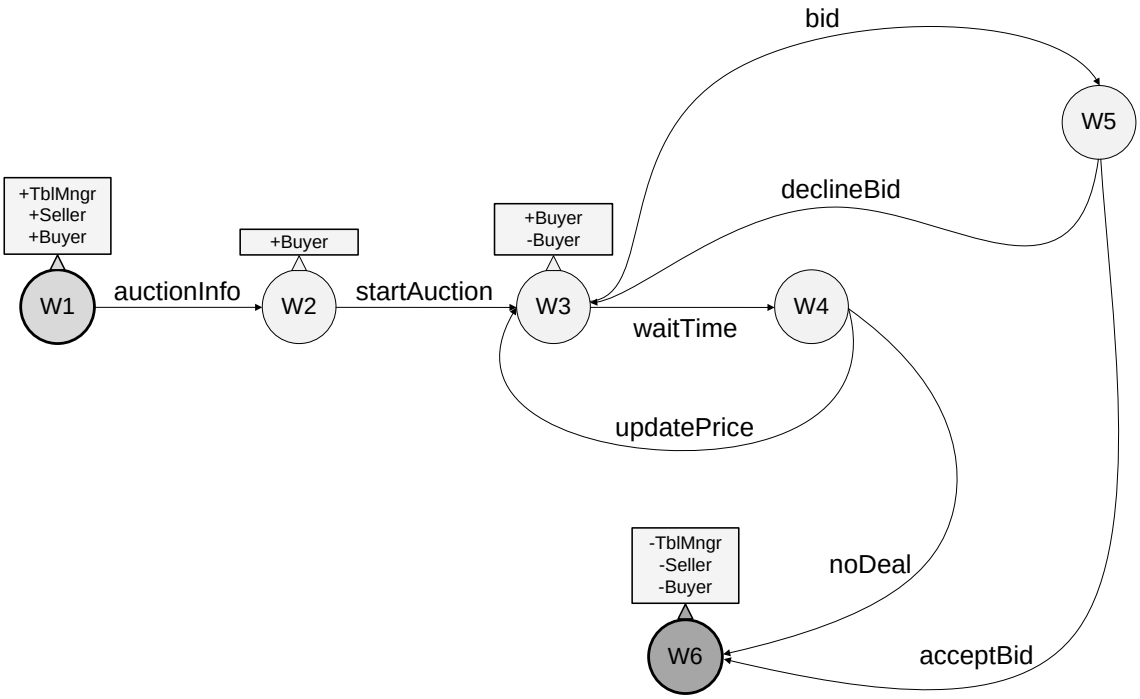

Figure 4.13: Scene protocol: Dutch auction

- W2: the vendor has sent the table manager all the information required to start the auction, and they both are waiting for a minimum number of buyers to start the auction.
- W3: the auction is running, and there is a defined price for the auctioned item. Buyers can bid the actual price at this point.
- W4: no buyer has placed a bid, therefore the item price will be decreased by a percentage of its initial price.
- W5: a buyer placed a bid for the actual price, so the table manager will check the buyer's credit and decide wether to accept or to refuse the bid.

The allowed messages to flow among the states are the following:

- W1 - W2: inform (?s Seller) (?t TblMngr) (dutchInfo ?price ?minPrice ?waitTime)
- W2 - W3: inform (!t TblMngr) (all Buyer) (startAuction ?item !price !waitTime)
- W3 - W4: [!waitTime]
- W3 - W5: inform (?b Buyer) (!t TblMngr) (bid)
- W4 - W3: inform (!t TblMngr) (all Buyer) (offer ?price)

- W4 - W6: inform (!t TblMngr) (all all) (close)
- W5 - W3: refuse (!t TblMngr) (!b Buyer) (bid)
- W5 - W6: inform (!t TblMngr) (all all) ?sale:Agreement

English Auction

Another possible negotiation protocol that a buyer and a seller may choose to trade water.

In the English auction scene (Figure 4.14), apart from the initial and final states (W1 and W6, respectively), we can find the following:

- W2: the vendor has sent the table manager all the information required to start the auction, and they both are waiting for a minimum number of buyers to start the auction.
- W3: the auction is running, and there is a defined price for the auctioned item. Buyers can bid the actual price at this point.
- W4: the wait time has passed and no buyer has placed a bid, so the auction finishes.
- W5: a buyer placed a bid for the actual price, so the table manager will check the buyer's credit and decide wether to accept or to refuse the bid.
- W6: if the bid is accepted, the price should be updated. If not, the price remains the same.
- W7: buyers may place a new bid in this state.
- W8: if the waiting time passes and no new bids are placed, the buyer with the current highest bid wins the auction, and therefore a new agreement is established between buyer and seller on the auctioned item.

The allowed messages to flow among the states are the following:

- W1 - W2: inform (?s Seller) (?t TblMngr) (englishInfo ?price ?waitTime)
- W2 - W3: inform (!t TblMngr) (all Buyer) (startAuction ?item !price !timeout)
- W3 - W4: [!timeout]
- W3 - W5: inform (?b Buyer) (!t TblMngr) (bid)
- W4 - W9: inform (!t TblMngr) (all all) (close)
- W5 - W6: accept (!t TblMngr) (?winner Buyer) (bid)

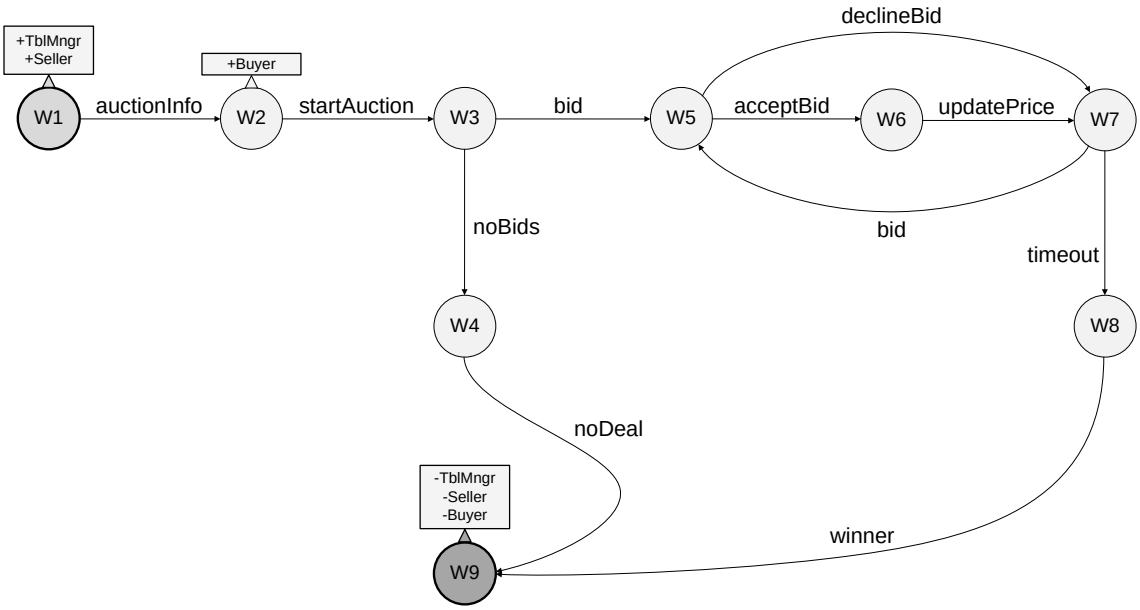

Figure 4.14: Scene protocol: English auction

- W5 - W7: refuse (!t TblMngr) (!b Buyer) (bid)
- W6 - W7: inform (!t TblMngr) (all all) (offer ?price)
- W7 - W5: inform (?b Buyer) (!t TblMngr) (bid)
- W7 - W8: [!timeout]
- W8 - W9: inform (!t TblMngr) (all all) ?sale:Agreement

Blind Double Auction

Another possible negotiation protocol that a buyer and a seller may choose to trade water.

In the Blind Double auction scene (Figure 4.15), apart from the initial and final states (W1 and W4, respectively), we can find the following:

- W2: the main state of the scene. Buyers and sellers must place their offers in this state, and the table manager will match them as they reach an agreed price. Once everyone of them have placed a bid, the table manager will communicate the bidders if their offers were successful or not.
- W3: if all the participants of the auction match their prices, the auction succeeds. In this state, the table manager informs buyers and sellers about the agreements and who will be the other trader.

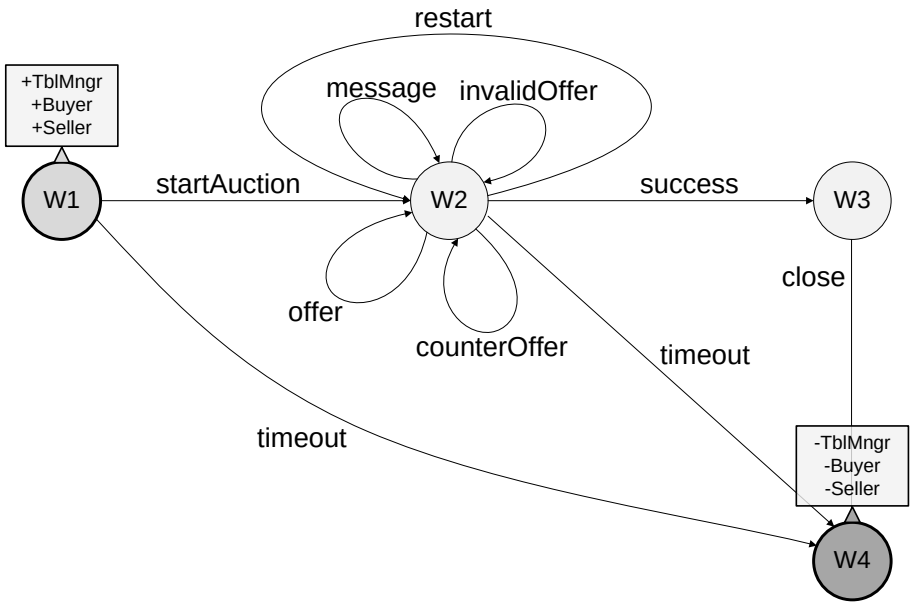

Figure 4.15: Scene protocol: Blind Double auction

The allowed messages to flow among the states are the following:

- W1 - W2: inform (!t TblMngr) (all all) (startDoubleAuction ?item ?timeout)
- W1 - W4: inform (!t TblMngr) (all all) (close)
- W2 - W2: inform (?x all) (!t TblMngr) (offer ?price)
- W2 - W2: inform (?x all) (!t TblMngr) (offer ?price)
- W2 - W2: inform (!t TblMngr) (?x all) (matched)
- W2 - W2: refuse (!t TblMngr) (?x all) (offer ?price)
- W2 - W2: inform (!t TblMngr) (all all) (restart)
- W2 - W3: inform (!t TblMngr) (all all) (auctionSuccesfull)
- W2 - W4: inform (!t TblMngr) (all all) (close)
- W3 - W3: inform (!t TblMngr) (?x Buyer) (matchDetails ?agreement)
- W3 - W3: inform (!t TblMngr) (?x Seller) (matchDetails ?agreement)
- W3 - W4: inform (!t TblMngr) (all all) (close)

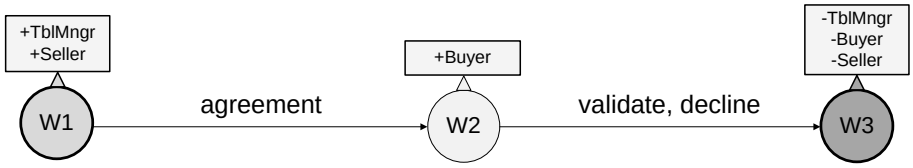

Figure 4.16: Scene protocol to conclude a negotiation: *Validation*

Validation

In the validation scene, a set of closing activities are executed, for example registering the final deals, stating the following steps for the agreement settlement, etc.

In the Validation scene (Figure 4.16), apart from the initial and final states (W1 and W3, respectively), we can find the following:

- W2: after the seller presents the corresponding agreement, the table manager has to confirm its validity refereing to the used negotiation protocol.

The allowed messages to flow among the states are the following:

- W1 - W2: request(?s Seller) (?t TblMngr) (validateAgr ?agreement)
- W2 - W3: inform (!t TblMngr) (!s Seller) (v_ok ?message)
- W2 - W3: inform (!t TblMngr) (!s Seller) (v_fail ?message ?reason)

Agreement Validation

Once an agreement on transferring a water right has been reached it is managed according to the market conventions. mWater staff check whether or not the agreement satisfies formal conditions and the hydrological plan normative conventions.

In the Agreement Validation scene (Figure 4.17), apart from the initial and final states (W1 and W4, respectively), we can find the following:

- W2: after the seller presents the corresponding agreement, the basin authority has to confirm its correspondence with the Basin Hydrological Plan (BHP).
- W3: if the agreement satisfies the BHP, the basin authority must check the agreement also satisfies the National Hydrological Plan.

The allowed messages to flow among the states are the following:

- W1 - W2: request(?b Buyer) (?ba BasinAuth) (validateAgr ?agreement)

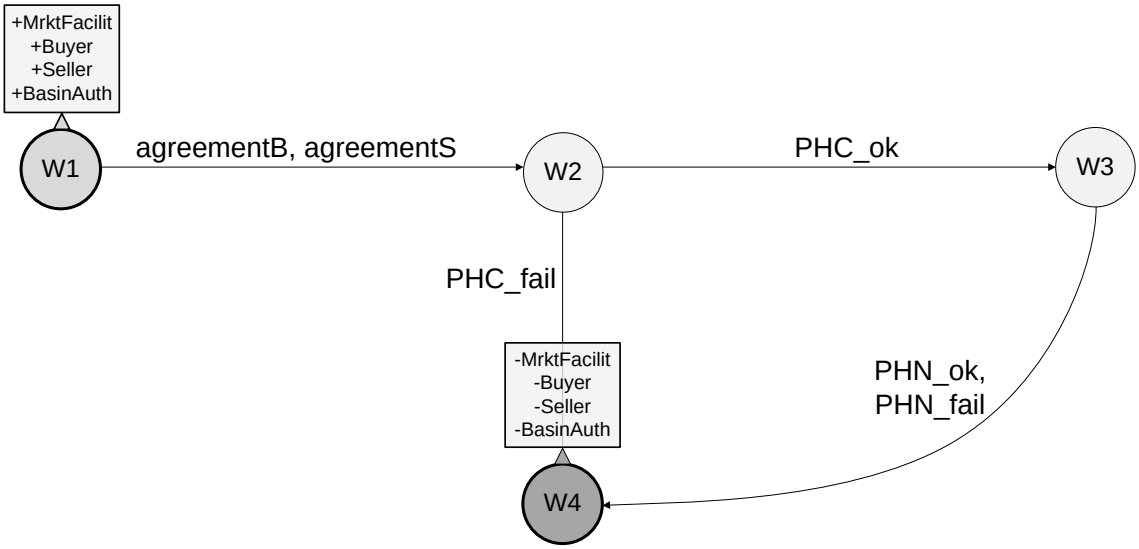

Figure 4.17: Scene protocol to check normative conventions: *Agreement Validation*

- W1 - W2: request(?s Seller) (?ba BasinAuth) (validateAgr ?agreement)
- W2 - W3: inform (!ba BasinAuth) (all all) (v_ok ?message)
- W2 - W4: inform (!ba BasinAuth) (all all) (v_fail ?message ?reason)
- W3 - W4: inform (!ba BasinAuth) (all all) (v_ok ?message)
- W3 - W4: inform (!ba BasinAuth) (all all) (v_fail ?message ?reason)

Contract Enactment

In this scene, a transfer contract is agreed upon and signed by the parties involved in the previous Agreement Validation scene, and then the agreement becomes active.

In the Contract Enactment scene (Figure 4.18), apart from the initial and final states (W1 and W5, respectively), we can find the following:

- W2: according to the national laws, before signing contract a period of 30 days must be granted, so any third party may present a grievance in case it is necessary. After that period passes,
- W3: the basin authority has presented the contract to both parties..
- W4: the seller has signed the contract. Now the buyer will proceed to sign.

The allowed messages to flow among the states are the following:

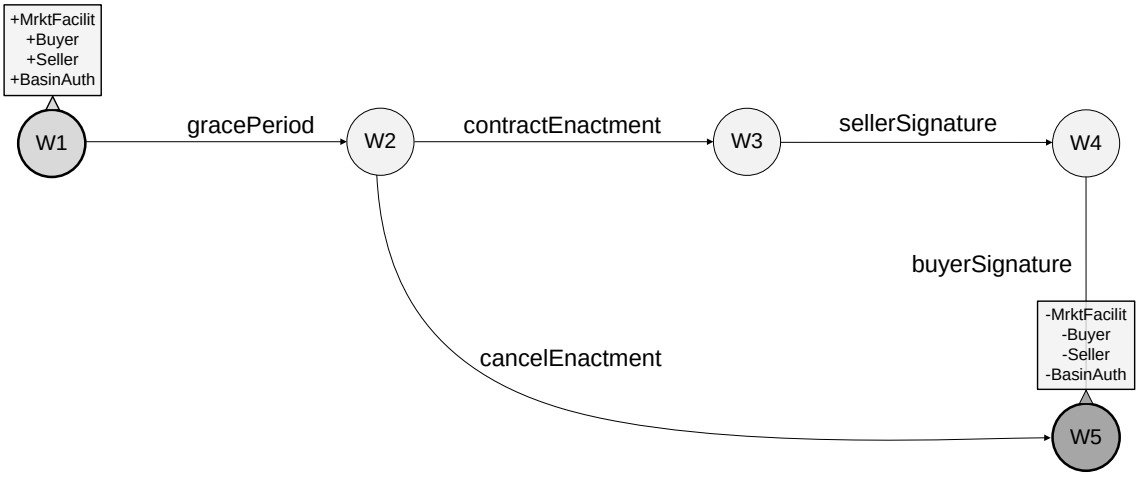

Figure 4.18: Scene protocol to sign a transfer contract and make it active: *Contract Enactment*

- W1 - W2: inform (?m MrktFacilit) (all all) (start)
- W2 - W3: inform (?ba BasinAuth) (all all) (contractEnactment ?contract)
- W2 - W5: inform (!m MrktFacilit) (all all) (close)
- W3 - W4: accept (?s Seller) (all all) (contractEnactment ?contract)
- W4 - W5: accept (?b Buyer) (all all) (contractEnactment ?contract)

Grievance Protocol

Any water user may initiate a grievance process in which (s)he exposes his/her arguments.

In the Grievance scene (Figure 4.19), apart from the initial and final states (W1 and W4, respectively), we can find the following:

- W2: the plaintiff may give new arguments to start a grievance procedure, or may finish its turn.
- W3: the plaintiff added a new argument, and the market facilitator will now consider it valid or not to start a new grievance process.

The allowed messages to flow among the states are the following:

- W1 - W2: inform (?m MrktFacilit) (all all) (start)
- W2 - W3: request (?p Plaintiff) (!m MrktFacilit) (newArgument ?message)

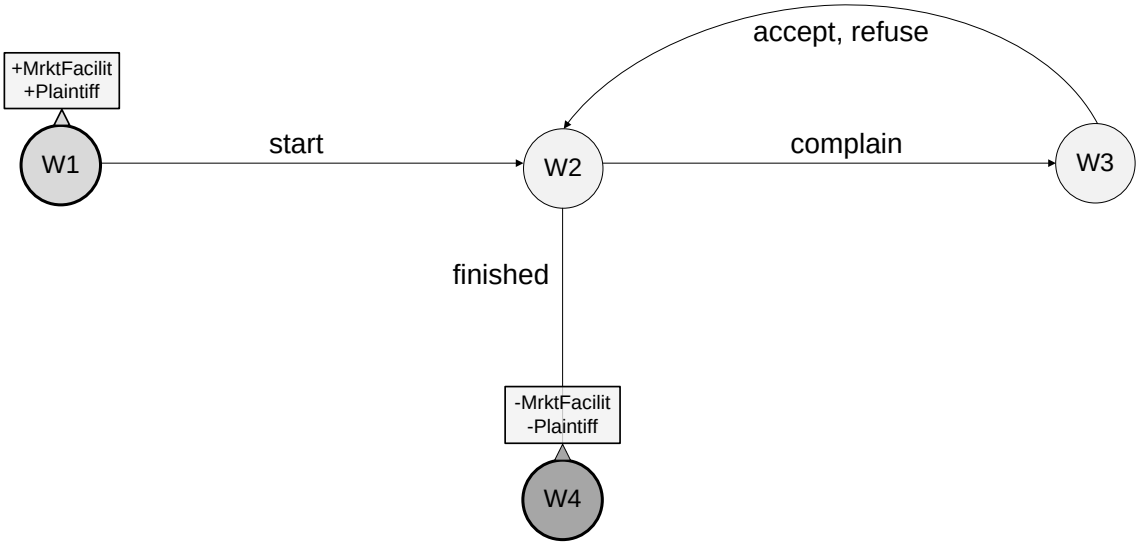

Figure 4.19: Scene protocol to expose the arguments for a grievance procedure: *Grievance Protocol*

- W2 - W4: inform (!m MrktFacilit) (all all) (close)
- W3 - W2: accept (!m MrktFacilit) (!p Plaintiff) (newArgument !message)
- W3 - W2: refuse (!m MrktFacilit) (!p Plaintiff) (newArgument !message)

Hearing Dispute

The market facilitator informs the affected parties of the dispute in order to execute their rights to appeal. A jury hears the dispute among the parties and determines the offenses.

In the Hearing Dispute scene (Figure 4.20), apart from the initial and final states (W1 and W5, respectively), we can find the following:

- W2: when all the required parties are present in the scene, the market facilitator commences the scene. From here, a plaintiff may present new charges or finish the dispute and wait for the jury verdict.
- W3: the plaintiff presented a new argument, and the affected may now present its own arguments to defend him/herself.
- W4: the plaintiff concluded the exposition of arguments. The jury will now present the conclusions.

The allowed messages to flow among the states are the following:

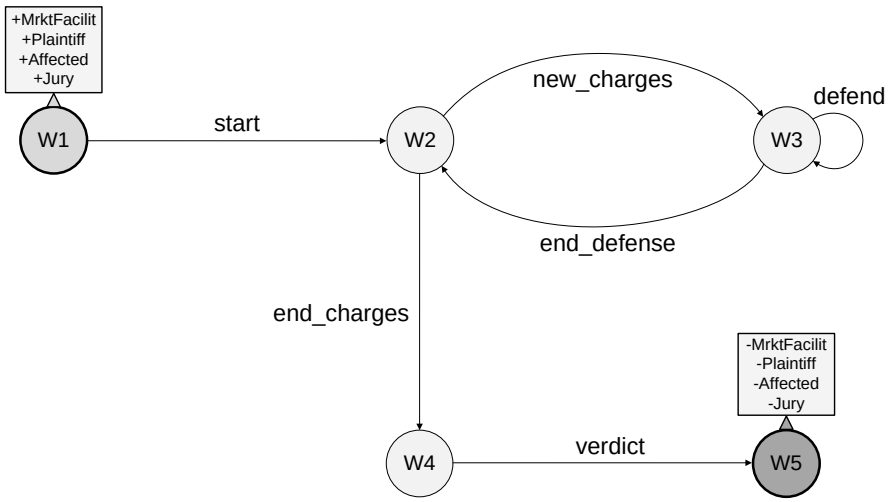

Figure 4.20: Scene protocol to expose the arguments about the dispute: *Hearing Dispute*

- W1 - W2: inform (?m MrktFacilit) (all all) (start)
- W2 - W3: inform (?p Plaintiff) (all all) (newArgument ?charges)
- W2 - W4: inform (!p Plaintiff) (all all) (finished)
- W3 - W2: inform (?a Affected) (all all) (finished)
- W3 - W3: inform (?a Affected) (all all) (newArgument ?charges)
- W4 - W5: inform (?j Jury) (all all) (publicVeredict ?veredict)

Sanctioning Offenses

In this scene, the third step, the Jury issues the sentence informing the parties the sanction.

In the Sanctioning Offenses scene (Figure 4.21), apart from the initial and final states (W1 and W4, respectively), we can find the following:

- W2: this is the main state in the scene. Once the jury and the affected party are present in the scene, the market facilitator commences the sanctioning process. From here, the jury will expose the sanctions.
- W3: the jury has exposed a sanction, and the affected party is required to accept it, as a proof to follow the market rules and conventions.

The allowed messages to flow among the states are the following:

- W1 - W2: inform (?m MrktFacilit) (all all) (start)

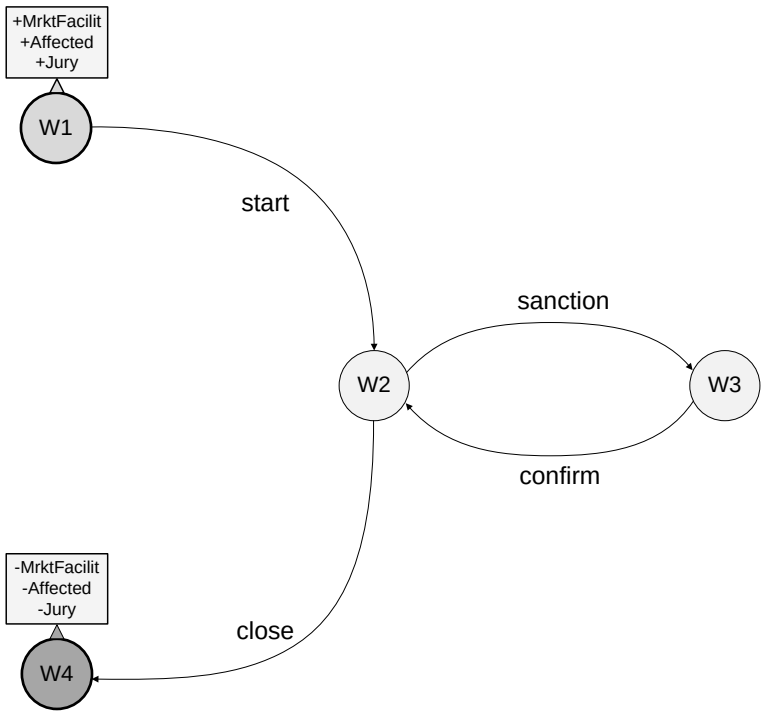

Figure 4.21: Scene protocol to issue the sanctions to the affected parties: *Sanctioning Offenses*

- W2 - W3: inform (?j Jury) (all all) (sanction ?desc)
- W2 - W4: inform (?a Affected) (all all) (sanction !desc)
- W3 - W2: inform (!m MrktFacilit) (all all) (close)

Annulment

This scene allows water users to quit the water market, assuring they have no unresolved issues, like pending sanctions, active agreements, or making sure they are not present in any negotiations or grievance procedures.

In the Annulment scene (Figure 4.22), apart from the initial and final states (W1 and W6, respectively), we can find the following:

- W2: the water user has requested his/her cease in the water market.
- W3: the water user has no pending sanctions.
- W4: the water user has no active agreements.
- W5: the water user is not present in any negotiations.

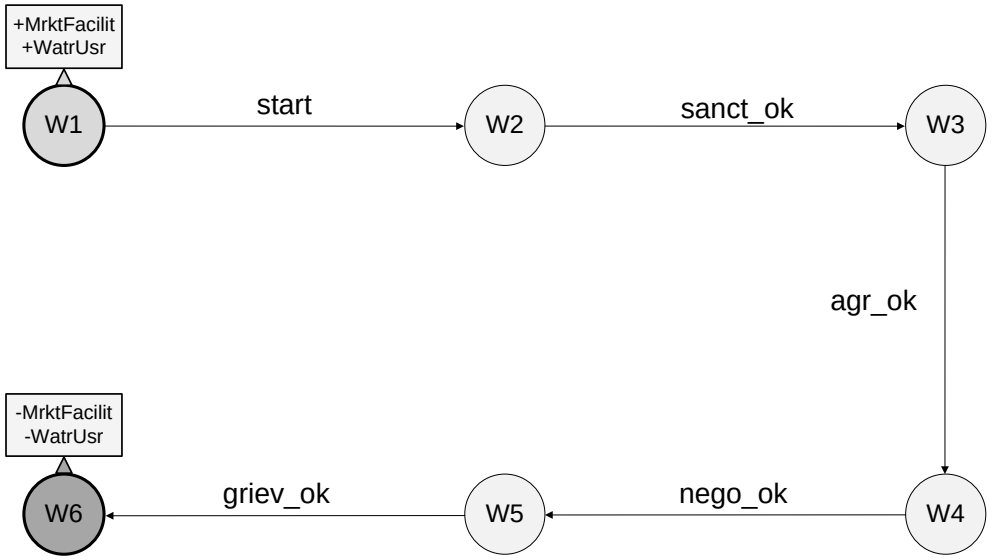

Figure 4.22: Scene protocol to log out from the water market institution: *Annulment*

The allowed messages to flow among the states are the following:

- W1 - W2: inform (?w WatrUsr) (?m MrktFacilit) (start)
- W2 - W3: inform (!m MrktFacilit) (!w WatrUsr) (v_ok ?message)
- W3 - W4: inform (!m MrktFacilit) (!w WatrUsr) (v_ok ?message)
- W4 - W5: inform (!m MrktFacilit) (!w WatrUsr) (v_ok ?message)
- W5 - W6: inform (!m MrktFacilit) (!w WatrUsr) (v_ok ?message)

Chapter 5

Conclusions and Future Works

As a whole, *mWater* constitutes a rather complex regulated open multi-agent system. It is designed with three objectives in mind. First, as a demonstrator in the AT project, it should provide a testing environment and inspiring problem domain for conceptual proposals and tools. Second, it may be used as the demand component of a sophisticated basin model to visualize and explore water management policies. That is, to explore the interactions between the basin hydrographic resources and infrastructures and the use of water as it is being modulated by market mechanisms and policy directives and regulations. Third, given the possibility of the creation of an actual market for water rights or analogous public goods, *mWater* would be a first proof of concept version to build upon.

The work we report in this deliverable provides the problem specification, and the analysis and design of the institutional framework for mWater prototype #1. We are now developing a richer electronic institution where scenes of the trading tables and the agreement management performative structures will be tailored to the two sources of inspiration of the demonstrator: i) to interaction conventions that are interesting for the testing of ideas developed in other work packages of the AT project, and ii) to interaction conventions that correspond to current practices and legislation. In this process we also improve the social structure of the framework to include specific staff roles for trading and conflict resolution mechanisms, auctioneers, arbiters, mediators, facilitators; as well as collective actors. Evidently, the ontology will need to be enriched and we shall begin to deal with the problems of anchoring dialogical terms (i.e. establishing the pragmatics of constants and relations in the communication language).

We have been able to delay the specification of software agents because we may use a human interface that is possible to build automatically from the specification by the aBUILDER tool. We will now start programming staff agents to manage the trading hall, different trading tables and a couple of on-line-dispute-resolution mechanisms, and pass our specifications out to other teams of the AT project so that they can use the demonstrator to test their agent architectures.

Our current *mWater* implementation reflects institutional normative requirements in

different ways through the standard EI constructs. Some non-procedural conventions are reflected in the dialogical framework. Some others are reflected as variable constraints or pre- and post-conditions of speech acts in the specification of scenes. Still some more in the decisional models of internal (staff) agents. We now want to incorporate declarative regulations as part of the scene specifications. This is possible thanks to recent extensions to the EIDE platform that couple an inference engine to the AMELI middleware, along the lines suggested in [GCNRA05].

An important effort in line with the tasks just outlined, is the compilation of conventional regulatory elements that affect water: legislation, local regulations and traditional social practices. One opportunity that we find specially attractive is the study of conflict-related social practices in the La Mancha Oriental basin.

The emphasis on regulatory aspects mentioned in the three last paragraphs is motivated by the fact that the main objective policy-makers have is to achieve the adequate behavior of user. And regulation is the main tool that policy-makers have to modify behavior. However, in practice, users are prone to achieve "order without law" [Ell91], or at least to keep on adapting to regulations in order to preserve their successful practices while policy-makers keep on adapting regulations to guide users in a constantly changing environmental and political media. Thus, our demonstrator should provide the foundations for the study of that interplay.

The *mWater* version presented in previous chapters is intended as the institutional foundation for further developments along the three modes of potential use of the MAS we mentioned at the beginning of this chapter. Although our immediate efforts concentrate on the test-bed conventions and functionalities, we will be keeping an open disposition towards the policy-simulation requirements. Thus, in future versions we will be including those functionalities that might be worth having in a policy-simulation environment —at the pace and depth the AT agenda indicates— but, for the time being, we neither intend to add simulation capabilities beyond those already available in SIMDEI and in the EIDE simulation service extensions (cf. [ANRAS07]), nor to merge *mWater* with conventional basin models. With respect to the market prototype, our strategy is to manage it as a by-product of the test-bed and simulation developments until the need or opportunity for an actual product arises. The reason is that we are building the *mWater* test-bed around a realistic institutional core with multiple functional add-ons that may be readily adapted to eventual regulations on the one hand, and market-design and testing requirements, on the other.

Apart from the previous ongoing works we can identify the following 2010 activities for Task 8.2:

- Specification of software agents for water users of the La Mancha Oriental basin.
- Working meetings with WP members of WP2, WP3 and WP4 in order to integrate results from these groups and to define possible inspiring domains for conceptual proposals and tools.

- A first implementation of *mWater* #1, which will include the performative structures and scenes identified in Chapter 4.
- Meetings with the *mWater* advisory board in order to evaluate prototype # 1 with experts of water related problems.
- Analysis and Design of *mWater* prototype #2, which will address Scenario #2 described in Chapter 3.

Contributing publications

The work of this package has contributed the state of the art with the following publications:

- V. Botti, A. Garrido, A. Giret, F. Igual, and P. Noriega. On the design of mWater: a case study for agreement technologies. In *Proceedings of the 7th European Workshop on Multi-Agent Systems (EUMAS 2009)*, 2009.
- V. Botti, A. Garrido, A. Giret, and P. Noriega. Managing water demand as a regulated open MAS. In *Proceedings of the MALLOW Workshop on Coordination, Organization, Institutions and Norms in agent systems in on-line communities (COIN@MALLOW'09)*, pages 108–109, 2009.
- A. Garrido, A. Giret, and P. Noriega. mWater: a sandbox for agreement technologies. In *Proceedings of the XII Congreso Catalán de Inteligencia Artificial (CCIA'09)*, pages 252–261, 2009.
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