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Towards a Utilized Ridesharing Service for Older People: A MAS Approach to Innovation

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Abstract. Technological and organizational innovations have promoted new modes of transport and services. Ridesharing has disrupted the entire transportation sector in the last decade, causing a cultural shift in the general population, but not so much in the older generations.

In this paper, we propose a multi-agent systems (MAS) approach to build an innovative mobility service that older people will utilize. To do this, we analyze the system of the ridesharing service of a French shared-mobility company, Mobicoop, revealing that indeed few older people utilize it. In the context of the MobiPA project, we look into the reasons that are hindering this utilization. We propose using a continual innovation method, ADInnov, to better understand and innovate on Mobicoop’s ridesharing ecosystem. Our proposal deals with each of the identified reasons by adopting MAS techniques and a socio-technical model. We describe the necessary concepts for modeling our multi-agent system, IMOPOP. In IMOPOP, we first use the Hodges’ Health Career Model, originating from the social care domain, to model the actors in the ecosystem, further proposing it as an organizational innovation. Secondly, we employ the contract net protocol for the negotiation between agents for a ride contract. Finally, we use Agent-Oriented Programming for modeling time in the system.

1 Introduction

In recent years there has been a significant increase in the number of companies working on improving or innovating transport services, or even developing new forms of transportation. Digital-age transportation systems have been changing rapidly in response to user needs. Services like Uber and Lyft have caused a breakthrough in the industry over the past decade, bringing back and popularizing the concept of ridesharing. Many others have ensued in the international or national scene. In France, BlaBlaCar has been the most popular ridesharing service, followed by other players, mainly regional, such as Mobicoop.

Mobicoop, previously called Covivo, is a shared mobility cooperative based in the northeastern French region of Grand Est. It was the first European actor to introduce a dynamic or real-time ridesharing [20] service. It has been working in

the transportation industry for ten years, providing citizens, companies and other clients with transport and technological solutions for ridesharing, carsharing and *transport solidaire*³. Its solutions have mainly been used by young generations and salaried workers⁴. There is one particular population *stratum* that still rarely uses these services – older people.

The questions that naturally come to mind are: what prevents older people from using these alternative cheaper-than-others mobility services? And ultimately, what would make them amenable to use these services, and how can we provide one that they will utilize⁵? To deal with these questions, the MobiPA⁶ (*Mobilité inclusive pour les Personnes Agées* – Inclusive Mobility for Older People) project was launched in 2018.

In this paper, the research question we raise is: *how can we build a complete innovative mobility service that older people will utilize?* As a starting point for an answer to this question, we propose to use a continual improvement and innovation method for complex ecosystems [14,17]. Through this method, we analyze and diagnose the problems in Mobicoop’s ridesharing service for the older people. Then, we propose to employ Multi-Agent Systems (MAS) techniques and a socio-technical model to deal with these problems.

The paper is organized as follows: Section II provides the motivation for our work, by researching the current state of ridesharing services in France and presenting some observations from the analysis of Mobicoop’s data. In Section III, we use a continual innovation method, ADInnov, in our ridesharing ecosystem. In Section IV, we present the proposed approach. Section V discusses our future work and presents concluding remarks.

2 Motivation

For a state of the art in ridesharing services, we collected information about those operating mainly in France using multiple criteria, some of which are shown in an excerpt in Table 1. This excerpt gives a list of services – provided by a company or an association – and their official website, their starting year, their main activity region, whether they provide a combination of different transport means (multi-modality), whether they provide their service in suburban or rural areas, whether they provide their service to older people, and elements that build trust between ridesharers. Out of the total list of services that we found, only a few dealt with transportation of older people, namely CityZen Mobility, Rezo Séniors, or Wimoov, and even fewer offered their services in suburban or rural territories – Rezo Séniors and Wimoov in the given list. Our work here, based on these observations, asserts that no mobility solution is being effectively used

³ Unpaid transportation of people in need done usually by volunteers or local organizations.

⁴ By sharing a journey or trip into work with a colleague.

⁵ Utilization implies the action of making practical and effective use of the service.

⁶ <https://mobipa.univ-grenoble-alpes.fr/>

Table 1: Extract of the state of the art in ridesharing services in France and proximate areas: the service, company or association and their official website, starting year, activity region, whether they provide a combination of different transport means, whether they provide service in suburban or rural zones, whether their service is targeting older people particularly, and elements that build trust, if available.

Service, Link, Year of creation	Location of activity	Multi-modality	Suburban/Rural	Older people	Trust Rating
Ecov, https://www.ecov.fr/ , 2014	Northwest of Île-de-France, Rhône, Bouches du Rhône	-	✓	-	Rating
Karos, https://www.karos.fr/ , 2014	Île-de-France, Normandy, Réunion Island	✓	✓	-	-
Taxito, https://www.taxito.com/ , 2015	Switzerland	✓	✓	-	Rating
CityZen Mobility, https://www.cityzenmobility.fr/ , 2013	Île-de-France	-	-	✓	-
Movici, https://movici.auvergnerhonealpes.fr/ , 2016	Auvergne-Rhône-Alpes	-	✓	-	-
Ecosystem, https://www.ecosystem.fr/ , 2013	Village of Ayen in Corrèze	-	✓	-	-
Rezo Séniors, https://www.rezo-seniors.org/ , 2018	Communauté de Communes du Plateau Picard	-	✓	✓	-
Wimoov, https://www.wimoov.org/ , 1995	Grand-Est, Île-de-France, Normandy, Nouvelle Aquitaine, Provence-Alpes-Côte d'Azur, Occitanie, Pays de la Loire	✓	✓	✓	-
Covoito, https://covoiteo.info/ , 2008	Toulouse	✓	✓	-	-
Padam, https://www.padam.io/ , 2014	Île-de-France	-	✓	-	-
Flexigo, http://www.flexigo.fr/ , 2018	Île-de-France	-	✓	-	-

by older people (including those living in peri-urban areas), even if they were designed specifically for them.

Furthermore, we analyzed the data that Mobicoop has collected from 2009 to 2018, using, first and foremost, the user database. This database contains around 357,000 records where we considered different criteria such as gender, birth date, home address, ratings of the mobility service, data on rides proposed and requested. We used the Elastic Stack [12], an open source tool, to first transform poor quality data, then analyze and visualize the data. Some notable observations are presented in Table 2:

Table 2: Demographic distribution of Mobicoop users

Criteria	Total	Older people (60 y.o. - 90 y.o.)
Number of users	356,923	11,172
- Female		5,921
- Male		5,251
Number of raters	1,748	543
Number of validations	131,773	6,193
- Number of offers		2,767
- Number of requests		3,426

- Out of the users that had declared their birth date, only $\sim 3\%$ had registered as older than 60 years old – considered as older people in the context of this study.
- Almost all older users had declared their gender: $\sim 53\%$ were females and $\sim 47\%$ were males.
- Only around 30% of the users that had given their ratings, and their birth date, were older people, of which $\sim 97\%$ had given top ratings.
- Out of the total number of rides that were validated (accepted by both parties), older drivers had made the lowest number of offers – $\sim 2\%$.
- Similarly, older passengers had made the lowest number of requests – $\sim 3\%$.
- Most of the geographical locations for ride origin for older people were municipalities, and for ride destination the city center, the train station, and pharmacies.

These results show that older people, especially those living far from urban centers, are hesitant in using Mobicoop’s ridesharing service to move around. This is the case even for those who might need to do so for urgent and important reasons, for example going to a doctor’s appointment or for groceries.

In the following section, we use a continual innovation method to look into the ridesharing ecosystem.

3 Using ADInnov for Examining a Ridesharing Ecosystem

Amey *et al.* [1] have identified the main challenges that ridesharing faces to be economic, behavioral, technological, and institutional. They state that initiatives and service innovations are necessary to deal with these challenges. The challenge that we face in our work here is the lack of utilization of ridesharing services by the older people. The reasons for this could be diverse and multiple. In this section, we make use of a continual innovation method to identify these reasons, and address them by innovating our ridesharing ecosystem.

Continual improvement or innovation is the ongoing process of improvement of products, services, processes, or technologies [30]. In [30], Tidd and Pavitt present a generic model of innovation, consisting of four phases: Search, Select,

Implement, and Capture Value. Different approaches on how to make innovation happen have been developed over the years. Two of the most popular improvement techniques that industrial organizations have adopted in the last few decades are lean management [18] and Six Sigma [2]. Six Sigma and lean management are mainly used to drive quality improvements and the elimination of waste, respectively. In lean management, continual improvement is also known as *kaizen* [15], which is an ongoing improvement involving everyone in the organization. There, Imai talks about the Plan-Do-Check-Act (PDCA) model [10]. Developed by Deming, the PDCA cycle is the most popular approach for continual improvement. It aims at introducing continual improvement based on achieved results. There have been variations of the PDCA cycle, such as the PDSA cycle [9]. The ADInnov method [5,6] follows the same principle of the PDCA cycle, but has been constructed empirically in the context of a complex socio-technical ecosystem. While all these techniques have proven effective in a full range of systems, to our knowledge, only ADInnov has been developed specifically for such ecosystems. For this reason, we use ADInnov, which allows us to analyze the ridesharing ecosystem in order to identify and diagnose its problems (characterizing the As-Is ecosystem), and then tackle them through innovation (resulting in an As-If ecosystem).

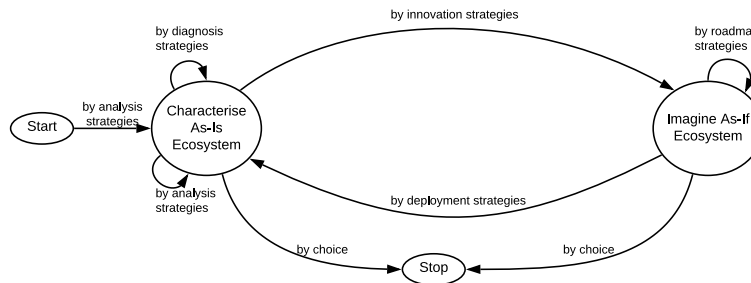


Fig. 1: The process model of the ADInnov method

ADInnov is composed of a process model (Fig. 1), based on the map formalism [24], and a product meta-model (Fig. 2). It consists of three phases – Analysis, Diagnosis and Innovation.

3.1 Analysis in ADInnov

As part of the Analysis phase, referring to the section $\langle \textit{Start}, \textit{Characterize As-Is Ecosystem}, \textit{by analysis strategies} \rangle$ in Fig. 1, the current ecosystem – As-Is ecosystem – is analyzed with the objective of identifying the target of the ecosystem, the Actors and their Functions, the Responsibility Networks, the Concerns, and the Service(s). It results in instantiations of the meta-model in Fig. 2.

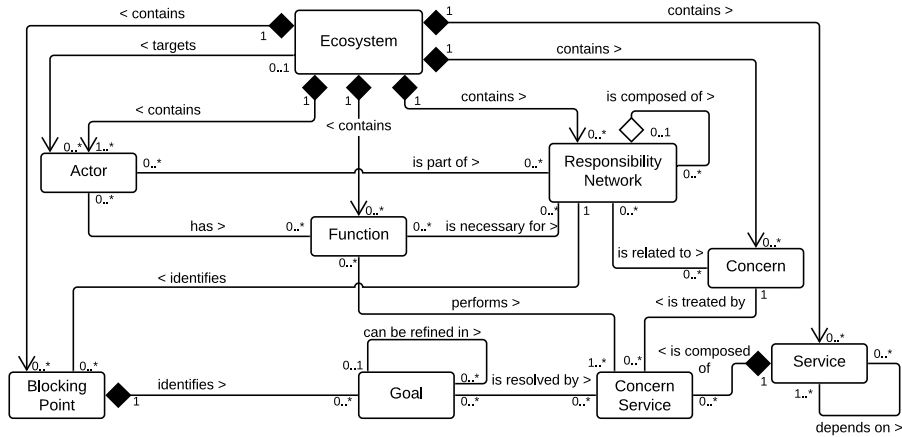


Fig. 2: The meta-model of ADInnov

An Actor is a type of physical or legal entity. Our ridesharing ecosystem is composed of many Actors, e.g. families, neighbors, physicians, Community Social Services (CSS). An Actor can have a skill or a responsibility – a Function – in the obtaining of the service in the ecosystem. Some Functions in our ecosystem include driver, health professional and local authority. To manage the complexity of the ecosystem, it is decomposed into Responsibility Networks. A Responsibility Network is a view of the ecosystem determined by the proximity of its Actors to the target – older people. We have identified the same Responsibility Networks for our ecosystem as in [6] – Regulation, Coordination and Execution. The Regulation network involves the laws and rules on ridesharing and transportation services. Coordination covers the organization of the Actors in the ecosystem. Execution refers to the close interaction of Actors in the ecosystem and the older people. The concept of Concern makes the ecosystem simpler – a Concern specifies one particular focus on the ecosystem. Concerns in our ecosystem can be technological, financial, social, legal. A Service is tied to a Responsibility Network and is composed of one or more Concern services. One Service in our ecosystem is the ridesharing service.

3.2 Diagnosis in ADInnov

During the Diagnosis phase, represented by the *<Characterize As-Is Ecosystem, Characterize As-Is Ecosystem, by diagnosis strategies>* section (Fig. 1), the Blocking Points of the ecosystem are examined and Goals for overcoming them are defined. Blocking Points are existing obstacles in the context of a Responsibility Network or a Concern. In the context of MobiPA, we used ADInnov means such as interviews and focus groups with older people in suburban areas to identify the Blocking Points (BP) of our ecosystem. These are:

1. Trust BP: Older people do not feel safe sharing their ride with people that they do not know previously.
2. Accompaniment/Assistance BP: Some need some level of assistance between their house and the car or the car and their place of destination.
3. User Preferences BP: Some have very specific and well-determined preferences, e.g. no desire to engage in conversation while sharing the ride, or strong feelings against smoking in the car.

Additionally, concerning the first BP, the focus groups revealed that most of the older people would not hesitate using a ridesharing service if a local organization or trusted person recommended it.

To resolve the BPs, Goals are developed in the ecosystem. We used participatory methods [4] to establish the Goals of our ecosystem, aiming at resolving each of the BPs mentioned above, such as to:

1. Increase the level of trust in the service.
2. Allow for accompaniment of or assistance to the older people from drivers.
3. Allow for a more complex service in order to consider the very specific user preferences.

We address the first Goal in section 4. By combining the two remaining Goals, we can define our (imagined) As-If service to be: A simple transport activity or an activity of transport and accompaniment/assistance, with a simple⁷ or complex⁸ journey, spread in one half-day, in one day, in several days, or with a time lag.

3.3 Innovation in ADInnov

The implementation of innovations happens in the third phase, which is represented by the section *<Characterize As-Is Ecosystem, Imagine As-If Ecosystem, by innovation strategies>* (Fig. 1). The Innovation phase outputs a set of imagined Services, where each Service addresses a specific Goal from the ones defined in the previous phase. The resulting is an As-If ecosystem. In our ridesharing ecosystem, we consider the result of focus groups, and propose an organizational innovation for resolving the Trust BP. Organizational innovations propose changes in the Actors, their Functions, the Responsibility Networks, or the Concerns. For the Accompaniment/Assistance BP and the User Preferences BP, using organizational innovations is insufficient. Given that ADInnov's main objective is to provide organizational innovations, we cannot use it as is for resolving these two BPs. Instead, we require a technological innovation in our ridesharing service, which will respond to the very specific preferences of older people, include optional accompaniment, and deliver trust. To this end, we propose using MAS techniques and a socio-technical model to generate a technological service innovation for ridesharing adapted to older people, which we present in the forthcoming section.

⁷ With the same departing and arriving point.

⁸ With different departing and arriving points, and one or more steps in between.

4 A Multi-Agent System for Innovation of a Ridesharing Ecosystem – Proposed Approach

Our ecosystem consists of humans, software application(s) and the physical world. Its organization is dynamic, which raises the need for an efficient integration of its components, while making them interact and cooperate in a flexible and consistent manner. Different actors have different objectives, hence different strategies. The global solution for the service is the result of the interaction between these many different strategies. Considering these aspects of our ecosystem, we rely upon computer simulations of the As-If ecosystem, resulting from the organizational and technological innovations, to help us materialize and reason about the new system and the techniques employed. Hence, taking a MAS approach, we represent our ecosystem as a multi-agent system, called IMOPOP (Inclusive Mobility for Older POPulations), where the agents represent the Actors of our ecosystem.

In this section we propose using models and techniques from the MAS and social care domains to introduce innovation in the ridesharing service. Simultaneously, we describe the modeling of the necessary elements of IMOPOP. We start with a hypothetical interaction between different actors.

4.1 Example of an Interaction Between Actors for a Ride

Lisa, an older person living in village V, needs to book a round trip for tomorrow to go from V to the nearest city C, for an appointment with her cardiologist at 9:00. Informed by her circle of friends and given that she does not have a smart phone, she knows that CSS can help her find a ride. She calls them and tells them about her constraint for assistance by the driver, and her preference of sharing a ride with a female driver. They give her the number that she should call. Lisa calls the number, and an operator gets the call. She tells the operator all the details about the ride. The operator tells her that they will call her back by the end of the day. The operator records Lisa's request on the ridesharing software (RS). By the end of the day, two users of the RS, David and Pauline, have offered a ride for tomorrow between V and C, the first leaving at 8:30 and returning at 16:00, and the second leaving at 8:45 and returning at 11:00. Both are willing to accompany the passenger, and both propose their rides for Lisa. The operator checks the received ride proposals. Both match Lisa's request, but considering her preference of traveling with another woman, the operator decides to select Pauline's. S/he calls Lisa and tells her that a female driver, Pauline, will drive her to her appointment in C tomorrow and back to V, and will accompany her to the cardiologist's. S/he also gives her Pauline's phone number.

The next day at 8:40, Pauline arrives at Lisa's home address and they leave for C. Upon reaching C at 9:00, Pauline helps Lisa to get out of the car and accompanies her to the cardiologist's office. At 11:00, Pauline meets with Lisa for their ride back to V. Once she drops Lisa home, Pauline indicates on the RS that the trip took place and writes a comment. Afterwards, an operator calls Lisa to ask her whether she was satisfied with the trip.

4.2 IMOPOP

The example above depicts an interaction for a ride between four types of Actors – passenger, CSS assistant, driver, and the RS – in a shared environment. In IMOPOP, this translates into sets of agents and sets of organizations that interact in the same virtual environment. This system, besides being dynamic, is also open – users can enter and leave the RS freely, and the same user can act as a passenger or a driver in a particular instance. In [8], Demazeau and Rocha Costa present a preliminary formal model for multi-agent systems with dynamic organizations through the toolbox approach to agent-oriented programming. Considering the commonalities between our system and the one dealt with in [8], we follow the same principle. It states that there are four sets of basic elements for the implementation of a multi-agent system: Agents, Environments, Interactions, and Organizations. Following, we model each of these four elements in IMOPOP, and then we add time dynamics to it.

The Agents. In [8], a population in a multi-agent system is described as consisting of the set of agents that inhabit it, along with the set of their possible behaviors, and the set of interactions that they can have.

Different agent types in a multi-agent system define separate populations. We have different types of Actors in our ecosystem (identified in subsection 3.1), each displaying different features. For this reason, we consider passengers and drivers to be two separate agent populations. Throughout this entire section, the passenger population always refers to older people. We add another agent population for intermediary Actors, such as the CSS in the given example.

In a system as complex as ours, we deem necessary that we take on an interdisciplinary approach. Kraus [19] states that this presents the challenge of choosing the right techniques to use. According to her, to select the most appropriate techniques, several factors should be taken into account, including the type and number of agents, regulations and protocols, the level of cooperation, along with communication and computation costs. In a situation such as ours, she encourages using models deriving from social and behavioral sciences to model communities. Conceptual socio-technical models have been developed to address challenges in various fields, such as [27] in health information technology, [25] in expert systems, [29] in e-government, [23] in higher education. But none of the models presented in these works is adapted to our context, firstly because their focal component is only the interaction between the social and the technical factors, and secondly because they are not domain agnostic. We choose a socio-technical model coming from the social care domain, called Hodges’ Health Career Model (H2CM) [11], which is domain agnostic and person-centered.

We use the H2CM model to address the identified BPs in our ecosystem in two different instances:

- in the modeling of the users of the RS in IMOPOP,
- as an organizational improvement, in the intervention of intermediary Actors in assessing older people to help them find a ride.

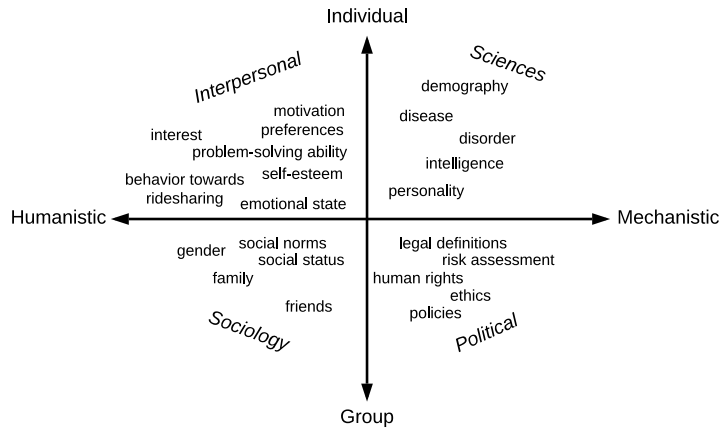


Fig. 3: Hodges’ Health Career Model for older people. This conceptual framework is organized into four knowledge domains (*Interpersonal*, *Sciences*, *Sociology*, and *Political*), which are the result of the intersection of two axes (Individual vs Group, and Humanistic vs Mechanistic). The positioning of features within a quadrant is irrelevant.

In the first instance, we use H2CM to model our passenger population, with the most exhaustive list of its features, which will identify user preferences or constraints, thus addressing the User Preferences BP. Exploring the internal structure of the agents has been shown to also help study the interaction process between them [16]. This means that we could observe if there is coordination or cooperation between the agents, which will be useful when we deal with the interactions between agents. The modeling of the passenger population, although perhaps never fully complete, serves for the modeling of our other two populations.

The H2CM model is structured around two axes, which create four knowledge domains. The vertical axis of individual and group indicates our primary focus on one side on the older person as an individual, on the other on the older people as a group. The horizontal axis separates features into humanistic – related to the social aspect of the older person/people, and mechanistic – related to the technical aspects concerning the older person/people. Fig. 3 shows the H2CM model for the passenger population, where we can see features identified and classified into four quadrants – Interpersonal, Sciences, Sociology, and Political.

In IMOPOP, an agent representing the older person is shown in Fig. 4. The agent (in the grey square) encapsulates the Older Person class, with Interpersonal and Sciences attributes, which result from H2CM. It can interact with the RS and Intermediary Actors. It can have a Close circle of family and friends (resulting from H2CM’s Sociology quadrant) and can own a Car. It plays a Function (identified in subsection 3.1), driver or passenger, which is constrained

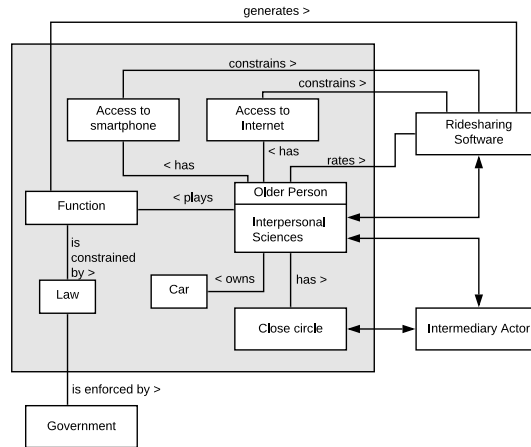


Fig. 4: UML representation of an older person agent in MobiPA with interactions and constraints from other agents in the environment. The agent itself is shown in the grey square.

by Law (part of H2CM’s Political quadrant), which itself is constrained by the Government. Functions generate the database of the RS. The agent can have Access to a smart phone and to Internet, both constraining the use of the RS. It can also rate the RS.

In the second instance, we propose that intermediary Actors use the H2CM model, as shown in Fig. 3, to identify user preferences when dealing directly with the passengers (as in the example in subsection 4.1). The inclusion of intermediary Actors in this process is in itself an organizational innovation.

The Environment. In multi-agent systems, the environment is generally considered implicit [32], but for the needs of our system it has to be modeled explicitly.

The environment represents a common place with certain characteristics and shared between the populations and organization(s) in the system. In [7], the environment is viewed as a set of agents and a set of environment resources. The latter include the services available in the area (the Actors identified in subsection 3.1), e.g. pharmacies, general practitioners, supermarkets; several parameters such as the distance of the older people’s home from any of these services or from the nearest public transportation, the opening and closing time of these services, which are also a constraint of the environment; and so on.

The Interactions. In order to share a ride together, passengers and drivers in our system have to interact – coordinate, or even cooperate. Coordination in multi-agent systems is defined as the management of dependencies between activities [21]. While in the recent years, there have been many applications of

different coordination techniques, such as [13] or [22], there have been no new techniques. Beer *et al.* [3] discuss about the different forms that negotiation between agents can take. These include protocols, auctions and argumentation. Considering that our target group are the older people, agents in IMOPOP should follow a very simple communication line, which should result in a mutually acceptable agreement. For this, the most appropriate form of negotiation are negotiation protocols, and the one that accomplishes this result with the minimum amount of communication is the contract net protocol [28]. Therefore, we use the contract net protocol for coordination in IMOPOP. The contract net protocol allocates tasks among autonomous agents, aiming to provide higher speed, reliability, and extensibility in the communication between agents in a typically spatially-distributed application. The contract net in our system is the set of agents (users) of the RS. Similarly to the user who can act as either a passenger or a driver, each agent can take on one of two roles, manager or contractor, but not both for a single interaction. For a particular interaction, one

<p>To: * From: Lisa/Operator Type: RIDE ANNOUNCEMENT Contract: 29-02-2020 Task Abstraction: share ride from V to C round trip accompaniment Eligibility Specification: must have proposed a ride must be leaving from V must be going to or through C must arrive in C around 9:00 Bid Specification: origin of the ride destination of the ride time of arrival at destination willingness to accompany gender Expiration time: 28 February 2020, 23:59</p> <p style="text-align: center;"><i>(a) Ride announcement.</i></p>	<p>To: Lisa From: Pauline Type: BID Contract: 29-02-2020 Node Abstraction: origin is V destination is C arrival at 9:00 round trip I am female I can accompany</p> <p style="text-align: center;"><i>(b) Ride bid.</i></p> <p>To: Pauline From: Lisa/Operator Type: AWARD Contract: 29-02-2020 Task Specification: origin is V destination is C arrival at 9:00 round trip accompaniment</p> <p style="text-align: center;"><i>(c) Ride contract award.</i></p>
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Fig. 5: Three messages in the contract net of users in the example given in subsection 4.1 negotiating for a ride through a ridesharing software

agent assumes the role of the manager – the passenger or an intermediary actor – and another agent the role of the contractor – the driver. Typically, the manager announces the trips for which s/he needs a ride. Then the contractor evaluates announcements for rides and bids on the ones suited to her/him. The manager receives the bids, evaluates them, and awards a contract to the most pertinent contractor. The contract could be passed at the end of the first interaction, or

the manager and the contractor can resume negotiation for certain details, such as adding a stop during the trip. The interaction is done by sending messages via the RS. These messages can be ride announcements, ride bids, ride contract awards, and others.

In Fig. 5 we give the negotiation between Lisa and Pauline using the contract net protocol. Fig. 5a shows a ride announcement message, where Lisa, through the operator – now acting as a manager – broadcasts her message for a ride to all the users of the RS, describing what she needs, the criteria that a driver must meet in order to be able to submit a bid, the expected form of a bid, and the deadline for receiving bids from drivers. We see in this message the constraint and preference for the driver – willingness to accompany and gender – which result from the modeling of Lisa as a passenger agent through H2CM. Fig. 5b shows Pauline’s bid message for Lisa’s announced ride. The message preserves the same bid format specified by operator/Lisa in Fig. 5a. The operator, after considering the ride bids from Pauline and David, determines that Pauline’s satisfies Lisa’s constraint and preference, and awards a ride contract to her (Fig. 5c).

The Organization(s). [8] defines an organization in a multi-agent system as a set of organizational roles and organizational links. An organizational role is the set of the agent’s behaviors which are part of the processes performed by a group of agents, while an organizational link is the mutual influence between agents in the group of agents performing a specific process in the system.

One agent organization in IMOPOP is Mobicoop. We entertain the possibility of there being other organizations in our system, such as Mobicoop’s clients and/or competitors.

Adding Time. The temporal factor is essential for a real-time ridesharing service – the interaction time between passenger and driver, the pick-up time, the arrival time. Furthermore, certain activities which prompt older people to request a ride, such as a doctor’s appointment or going to the movies, are time-constrained. Therefore, we give priority to such activities.

A passenger and a driver start negotiating for a ride at the time of negotiation. The negotiation can last for a short time or up until expiration time (seen in Fig. 5a). From the time of negotiation until the award of a ride contract, both passenger and driver could change their minds, availabilities, preferences, or constraints. For this reason, we add a clock in IMOPOP, which ensures that agents are intrinsically real-time. This concept comes from [26], where Shoham introduces the Agent-Oriented Programming paradigm, according to which an agent has a mental state made of beliefs, capabilities, decisions, and obligations. At regular intervals, agents update their mental state based on previous changes (e.g. as a result of an interaction), and execute the commitments (e.g. a ride) for the current time. The clock makes sure that this two-step loop is initiated repeatedly at regular intervals.

When a ride contract has been awarded, it means that at the time of execution, i.e. when the ride happens, the passenger, the driver, and either the driver’s or the passenger’s car are available⁹.

5 Conclusion and Future work

In this paper, we have demonstrated that most of the older people are not utilizing available ridesharing services, for various reasons. Here, we have explored these reasons within the context of the MobiPA project.

To tackle this problem, we have used the ADInnov method to introduce innovation into a ridesharing ecosystem. Firstly, we have analyzed the ecosystem to find its target, and identify the actors and their functions, the responsibility networks, the concerns, and the mobility service. Secondly, we have diagnosed the ecosystem and identified three major blocking points: trust, accompaniment or assistance and user preferences. Subsequently, we have defined goals to resolve them. The combination of these goals has defined our mobility service – a simple transport activity or an activity of transport and accompaniment; with a simple or complex journey; and spread in one half-day, in one day, in several days, or with a time lag. Thirdly, to introduce innovation in the ecosystem, we have adapted MAS techniques and a socio-technical model. We have described the concepts for modeling our multi-agent system, which we called IMOPOP. The socio-technical model that we have used is the Hodges’ Health Career Model, which captures the user preferences blocking point and models the older people in IMOPOP. We have addressed the trust blocking point by proposing that this model be used as an organizational innovation of the ecosystem. Then, we have employed the contract net protocol for the cooperation between agents. This negotiation can take place between multiple agents, with the objective that the older person be able to determine and select the ride that will satisfy their preferences and possible constraints, leading to a ride contract. Finally, we have described the elements that we take into account for modeling time in our system.

In future work, we will formalize the proposed multi-agent system with a meta-model like in [31]. Then, we will move from the conceptual model to the implementation of the multi-agent system. This will allow us to simulate the system using scenarios resulting from the MobiPA project, and to afterwards validate it.

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⁹ We consider the case when the passenger has her/his own car but cannot drive it. In such a case, the person acting as driver can drive the passenger’s car.

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