Ontology of Social Service Needs: Perspective of a Cognitive Agent

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Abstract. This paper proposes an ontology of social service needs for the evaluation of social service providers. Existing ontologies in the social service domain define metrics to evaluate the efficient use of resources by service providers. The ontology presented here represents service provisioning from the perspective of a cognitive and goal-driven client to evaluate services based on how well they remove a client's constraints and meet client needs. This ontology is grounded in real-life requests made by participants of a Housing First intervention program, resulting in 57 different goal types. Each goal is mapped to one or more basic human need defined by Maslow's Hierarchy, as inferred from the goal's type, the motivation behind it, and the client's demographics. Finally, as clients interact with service providers, three different types of goal orderings are required to capture goal ranking during the planning and execution phases. These include the client's preferred order, Maslow's hierarchy order, and the practical order imposed by the logistical constraints of service providers.

Keywords. goals, agent-based simulation, cognition, ontology, human behaviour

1. Introduction

This paper proposes an ontology of needs for human-like agents that interact with a social service provisioning system. The ontology is based on data about the types of requests made by social service clients in a real-life intervention program. Existing ontologies focus on the process of service delivery, categorizing services and resources to ensure an efficient provisioning to incoming clients [1,15,11]. In the work proposed here, an ontology is created that allows for the evaluation of service provisioning from the client's perspective. By identifying goals of clients and the services that satisfy them, it is possible to create a high-fidelity client emulation model for the purpose of social service evaluation [3]. Towards such a model, the ontology presented here provides competencies not yet provided elsewhere. The ontology is used to identify relationships between clients and service providers, including client needs, constraints, and motivations. The ontology also differentiates service-side concepts like resources, programs, and a metric for client outcomes. To support a cognitive agent, the ontology makes a destination between three different goal ranking used for goal reasoning and planning [3]. First, the ontology can be used to infer correct needs associated with Maslow's hierarchy, by providing a set of

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domain-specific mappings between data provided by services and the hierarchy based on theoretical analysis of needs [10]. Second, a client's own preferred ranking can be identified based on order requests are made on questionnaires and service request forms. Third, the practical ranking represents the order goals were actually satisfied in by services, as captured by service-side data, and takes into account environmental constraints imposed on the service provider.

Generally, human needs are difficult to capture. There are several theories that define motivation as "drives", but these are too vague and inflexible to construct a computational model of a cognitive agent's motivations and preferences [9]. Instead, goals are provided *a priori* and influence a goal-driven agent's behaviour [3]. By evaluating the social service delivery process through data provided by participants in a real-life intervention program, an ontology is developed that captures the relation between client goals and the services they use.

There are several ontologies that capture social service provisioning from the provider's perspective [1,15,11]. However, no ontology exists that focuses on client needs and motivations from the client's perspective. At the same time, human motivations have long been credited with influencing decision making in the social service domain [2]. To assess a client's current state, questionnaires such as the "Service Prioritization Decision Assistance Tool" (SPDAT) capture past and current needs. Once a client's state and outstanding needs have been identified, techniques like Motivational Interviewing and Acceptance and Commitment Therapy are used to facilitate change in their behaviour that aligns with the clients motivating factors [2].

The proposed ontology provides an ontological representation for four aspects of social service client needs missing today. First, client needs made up of 763 requests found in the data are categorized into 57 different goal types. Each type is defined by the agent's motivations, constraints, resources needed, and the services offering those resources. Second, the relation between a client and a service provider is based on the constraints faced by clients, not services. Third, each goal type has a homeless-specific mapping to one or more levels of Maslow's hierarchy. Such mappings are not trivial, and the ontology infers appropriate mappings based on request types and client characteristics. Fourth, three goal orderings are identified for different phases of a client's interaction with the provider. These include client preferences during the planning phase, Maslow's order during plan execution phase, and practical ordering based on logistical constraints placed on the service provider.

2. Method

To capture how a service provider satisfies goals of clients, this paper develops the Ontology of Social Service Needs (OSSN). The ontology is developed using the ontology engineering method. Ontology engineering is a systemic way of constructing and evaluating an ontological representation of a domain [6]. First, motivating scenarios are identified to define the scope and objectives the ontology is meant to resolve. Second, a set of informal competency questions are defined which the ontology should answer. Third, an ontology is constructed that represents knowledge required to answer identified competency questions. Finally, the informal competency questions are translated into formal competency questions using the terminology and formal language that allows for the automation of querying identified questions. The work presented here represents the ontology in OWL

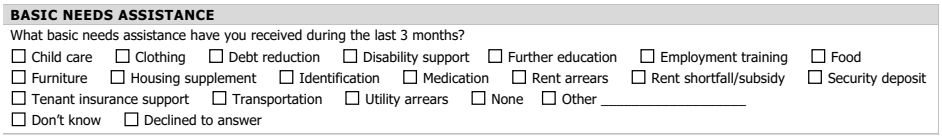

Figure 1. CHF version of SPDAT section for capturing requests for basic needs made by clients.

syntax. The SPARQL query language is used to represent formal competency questions, with a complete evaluation in Gajderowicz et al. [5].

2.1. Homeless Data

The Calgary Homeless Foundation (CHF) [2] has provided a dataset that captured information about clients as they participate in a "Housing First" (HF) intervention program administered by CHF. The CHF-HF dataset contains information on approximately 4,000 unique clients that participated in the HF program in Calgary, Canada from 2009 to 2015. The information was collected using SPDAT questionnaires. A complete description of the data and analysis is provided in [5]. Based on the data, the ontology categorizes clients according to fifteen key demographics. SPDAT also captures different client requests for basic needs, as per Figure 1. Participants were surveyed at program intake with follow-up interviews every three months until exiting the program. By grouping 763 unique requests captured, 57 need categories represent goal types in the ontology.

2.2. Motivating Scenarios

Motivating scenarios for the OSSN focus on the evaluation of social service policy from the perspective of clients that use them. These include:

- How to evaluate intervention programs in the social service space?
- How to monitor client progress?
- How to monitor service delivery performance?

The general approach to evaluating a program is to identify the percentage of clients who were successful [4]. The criteria for eligibility into a program is the probability a participant will be successful based on their information at intake. With the HF program, it is not clear which cohorts will be successful [14]. Since simply relying on demographics is not sufficient, the motivating scenarios arise from the need to understand the interaction between clients and services as they participate in the program to meet their needs.

2.3. Competency Questions

The focus of the competency questions for OSSN is to answer queries about the relationship between client needs and service providers captured by SPDAT questionnaires. Client questions address the three main concepts captured about clients, their needs, constraints, and demographics. For the complete list of questions see [5].

Q-1 Which demographic is asking for MH need X most?
Q-2 Does client X ask for goals in the same order as client Y?

[2] The Calgary Homeless Foundation: `http://calgaryhomeless.com/`.

Q-3 What constraints clients with demographic X?
Q-4 Are wrong conditional goals assigned to any client?
Q-5 What services are needed together to address "childcare goals"?
Q-6 What resources and service are needed to address a client's security level needs?
Q-7 How well do programs address physiological and security needs of clients?
Q-8 Are resources available when needed?

The first group is a sample of questions (Q-1 to Q-4) that examine the ontology's ability to represent data provided in the CHF-HF SPDAT dataset. Focus is placed on the requests made by clients. This includes mapping the requests to Maslow's hierarchy, capturing the order of requests, and associating them with possible motivations and constraints that prompted the requests. Using the provided demographics, OSSN infers the correct MH level to map participant requests to. The second group is a sample of questions (Q-5 to Q-8) that evaluate the ontology's ability to capture services available to clients. By associating services with client constraints, the objective is to answer questions about service provisioning from the perspective of the client.

3. Engineering the Ontology of Social Service Needs

To engineer our ontology of needs, we first analyze how Maslow's hierarchy can be applied to this domain to create a domain-specific mapping. We then identify high-level concepts required to categorize requests and present axioms included in the ontology.

3.1. Maslow's Needs for Homeless Clients

While basic motivation for human needs is ill-defined [9], there is some consensus that behaviour models can rely on theories like Maslow's hierarchy (MH) for grounding goals in basic human needs [10]. A need can be considered as a "master" goal, an innate requirement for an agent without a triggering activity. Such needs always exist with varying degrees of urgency. All other goals or sub-goals are regarded as tangible states that can be achieved and satisfied through a series of activities. MH categorizes tangible goals into five categories of basic human needs. While there is mostly consensus on the categories, there is less consensus on the correct order of MH levels and whether it can be applied universally across populations and cultures [13,7]. Generally, the first group of needs are short-term needs important to our survival. The second group includes long-term needs that serve to improve our life and society at large.

The mapping of goals to MH level needs is especially problematic for the homeless population. Mappings are conditional on a combination of demographics, goal types, and previously satisfied goals [12,7]. For example, *housing* (long term) and *housing temp(orary)* is only a physiological level need for absolutely homeless, and a security need for relatively homeless. Also, family needs are not necessarily a social level need. For example, when providing for a child's needs, the goal is mapped based on the needs of the child. However, any motivations and constraints are those of the agent. Also, not all mappings are direct, one-to-one mappings between a need and an MH level, as discussed in section 4. Some span multiple levels at once, while others are spread across multiple levels to be satisfied in a sequence over an extended period of time. For example, requesting *laundry* services impacts a client's self esteem, ability to socialize, and

Table 1. Maslow's hierarchy of needs mapped to SPDAT requests according to [5].

MH Need	SPDAT Request
None	None, declined to answer
Self-actualization	Addiction support, case management, child care, education, employment training, family support, goods misc, life skills, referral, social
Esteem	Computer, counseling, debt reduction, disability support (for relatively homeless), education, employment training, family support, forms, goods family, goods infant, goods misc, hygiene, identification, laundry, life skills, money family, money planning, money social, phone (for non-elderly), referral, tenant insurance support, transportation
Social	Aboriginal, child care, computer, counseling, disability support (for relatively homeless), education, forms, health support, hygiene, immigrant services, laundry, life skills, miscellaneous support, money family, money social, phone (for non-elderly), referral, social, social family, transportation, utility arrears
Security	Advocacy help, advocacy legal, child care, clothing, counseling, disability support (for absolutely homeless), don't know, forms, goods infant, goods misc, health support, housing (for relatively homeless), housing goods, housing maintenance, housing safety, housing supplement, housing temp (for relatively homeless), hygiene, identification, immigrant services, income, laundry, medication, mental issues, money goods, money health, moving, phone (for elderly), referral, rent arrears, rent shortfall/subsidy, security, security deposit, tenant insurance support, transportation, utility arrears
Physiological	Addiction support, food, furniture, home goods, housing (for absolutely homeless), housing temp (for absolutely homeless), mental issues

prevents violence from others, hence is spans the esteem, social, and security levels. The final mappings for 57 goal types consolidated from the 18 request types captured by the SPDAT questionnaire section in Figure 1, including 745 entered by clients in the "other" fields, are provided in Table 1 with a complete analysis in [5].

3.2. Ontology of Social Service Needs

Based on the client requests captured in the CHF-HF dataset and directly, conditionally or unconditionally mapped to MH levels, the following ontological entities are represented. An agent's relation to their goals and the services they use is represented by the Ontology of Social Service Needs (OSSN). This relation is comprised of its Maslow **need** and order ranking, followed by a concrete **goal** requested by a participant, personal **motivation** for that goal, and **constraints** preventing goals from being satisfied. The agent's need is mapped to an MH level. **Motivation** is a description of why an agent might want to pursue this goal. It provides additional information for mapping a goal to the appropriate MH level. For example, "childcare" is a broad category of needs associated with the agent's child's needs. The motivation to keep a child out of harm's way would associate a goal with the physiological level, as it prevents physical harm. This may include a request for emergency childcare and contacting child protective services. Child care may also be motivated by wanting to raise well-adjusted and social children and mapped to the agent's esteem level.

The service provider is represented with resources and services that relieve an agent's constraints. A **constraint** is a high-level summary of unsatisfied preconditions preventing an agent from achieving their goals. The preconditions are satisfied by social services that provide **resources**. For example, the constraint preventing an agent from providing toys or social activities for their children might be a lack of money or not

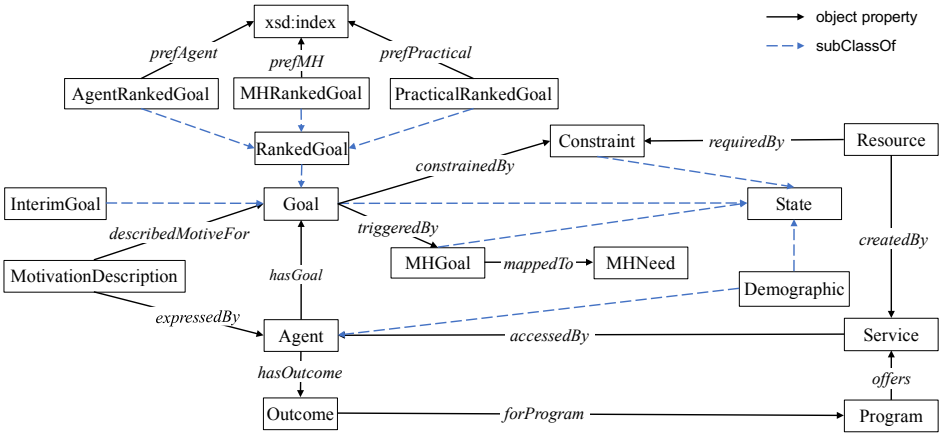

Figure 2. Ontology of Social Service Needs knowledge graph.

knowing about available activities (i.e. lack of information). The **service** represents the service provider, program, or department that makes the resource available to the agent.

3.3. OSSN: Formal Definitions

This section provides the formal definitions for OSSN, represented in OWL syntax [8]. The OWL (Web Ontology Language) was chosen since it is one of the most common ontology languages on the Semantic Web. Main OSSN classes and properties are represented in Figure 2. **Agents and Goals** Clients are represented as human-like and goal-driven agents. Hence, the property *hasGoal* defines the *Agent* class as one that has at least one *Goal* state, as per Axiom 1. Axiom 2 defines the *Goal* class as a state triggered by some underlying MH need, but constrained from being true. The $MotivationDescription$ class captures the agent's expressed motivation for requesting a goal, as per Axiom 3.

$$Agent \sqsubseteq \exists hasGoal.Goal \tag{1}$$
$$Goal \sqsubseteq State \sqcap \exists triggeredBy.MHGoal \sqcap \exists constrainedBy.Constraint \tag{2}$$
$$MotivationDescription \sqsubseteq \exists describedMotiveFor.Goal \sqcap \exists expressedBy.Agent \tag{3}$$

Goal Constraints A goal state is constrained by the *Constraint* class, a state that summarizes unmet preconditions that prevent the goal state from being true. For example, an agent cannot buy food from a store if they do not have money. Having money is a precondition state that must be true before purchasing food. The state $lackOfMoney$ is a *Constraint* that prevents the *Goal* class *moneyForFood* from becoming true. For a state to be a constraint, it must also be resolvable by a resource. A non-resolvable constraint identifies an incorrect goal or action. For example, requesting legal advocacy from a housing worker describes an incorrect action if the goal is to find housing. Hence a *Constraint* class is a *State* class that requires a *Resource* class ($requiredBy^{-}.Resource$) and is actively constraining a *Goal* class ($constrainedBy^{-}.Goal$), as defined in Axiom 4.

$$Constraint \sqsubseteq State \sqcap \exists requiredBy^{-}.Resource \sqcap constrainedBy^{-}.Goal \tag{4}$$

MH Goals And Interim Goals Requests made by agents to satisfy expressed goals are triggered by an underlying MH level need associated with it. $MHGoal$ represents such a

need that triggers the requested goal. Each *MHGoal* is mapped to one or more MH levels. For example, while *moneyForFood* is a *Goal*, *notBeHungry* is the *MHGoal* state that triggers it. *notBeHungry* is then mapped to the "physiological" MH level. In OSSN, the *triggeredBy* property captures the relation between a requested *Goal* and its underlying *MHGoal*. The *mappedTo* property captures the relation between the *MHGoal* and its underlying MH level class *MHNeed*. These classes are defined in Axioms 5 and 6.

$$MHGoal \sqsubseteq \exists triggeredBy^{-}.Goal \sqcap \exists mappedTo.MHNeed \tag{5}$$

$$MHNeed \equiv \exists mappedTo^{-}.MHGoal \sqcap \{physiological \sqcup security \sqcup social \sqcup esteem \sqcup selfActualization\} \tag{6}$$

$$InterimGoal \sqsubseteq Goal \sqcap \neg \forall mappedTo.MHNeed \tag{7}$$

Finally, interim goals are sub-goals required to satisfy preconditions of actions that satisfy existing goals. For example, walking to the store to buy food is an interim goal. The *InterimGoal* class is defined as a subclass of *Goal* that is *not* mapped directly to an MH level, as defined by Axiom 7.

Agent Demographics An agent's demographics are used to automatically infer conditional mapping. A conditional goal is a type of *MHGoal* class mapped to an MH level based on an agent's *Demographic* class. For example, consider the examples in section 3.1. The goal of temporary shelter for agents in the "absolutely homeless" demographic is mapped to the physiological MH level. For agents in the "relatively homeless" it is mapped to the security MH level. A *Demographic* is a subclass of *State* class that defines the state of an agent, as per Axiom 8.

$$Demographic \sqsubseteq State \tag{8}$$

$$\top \sqsubseteq \forall homelessState.\{abs, rel\} \tag{9}$$

$$AbsHomeless \equiv Demographic \sqcap homelessState : abs \tag{10}$$

$$RelHomeless \equiv Demographic \sqcap homelessState : rel \tag{11}$$

$$AbsHomelessAgent \sqsubseteq Agent \sqcap AbsHomeless \tag{12}$$

$$RelHomelessAgent \equiv Agent \sqcap RelHomeless \tag{13}$$

$$\bot \sqsubseteq AbsHomeless \sqcap RelHomeless \tag{14}$$

Demographic properties define the actual "demographic" state true for the agent. For example, the following axioms define how to identify an agent as either absolutely or relatively homeless. First, the property *homelessState* in Axiom 9 has a range of "abs" and "rel" to represent an absolutely and relatively homeless status, respectively. Next, Axiom 10 defines the *AbsHomelessState* class as the intersection of the *Demographic* class and a class for which *homelessState=abs*. Similarly, Axiom 11 defines the *RelHomelessState* class as the intersection of the *Demographic* class and a class for which *homelessState=rel*.

Next, to assert that an agent is absolutely homeless, *AbsHomelessAgent* is the subclass of the intersection between the *Agent* and *AbsHomeless* classes, as defined in Axiom 12. For some agent *A* the assertion $AbsHomelessAgent(A)$ categorizes *A* as an absolutely homeless agent. Its relatively homeless counterpart is defined in Axiom 13. Since absolutely and relatively homeless types are disjoint sets, having the same agent classified as both produced an inconsistent ontology, as per Axiom 14.

Service Provider and Resources The service provider is represented by the *Service* class. A service is something that can be accessed by an agent and creates resources,

as defined in Axiom 15. For example, a "social worker" is a multi-functional service offered by a shelter. A social worker can provide a variety of resources, such as booking a bed, information about childcare, or finding a suitable mentor. It follows then, that the *Resource* class is defined as something a service creates and that is required by a *Constraint* class, as defined by Axiom 16.

$$Service \sqsubseteq \exists accessedBy.Agent \sqcap \exists createdBy^{-}.Resource \tag{15}$$
$$Resource \sqsubseteq \exists createdBy.Service \sqcap \exists requiredBy.Constraint \tag{16}$$

Program and Agent Outcome The last set of main classes OSSN supports are those that capture an agent's outcome in a program that offers multiple services. An agent can access a service, but their outcome is evaluated in the context of the program. Hence, a *Program* class is defined as the intersection of classes that offer a *Service* and have an *Outcome*, as per Axiom 17. The *Outcome* class relates an agent's status to a program, as per Axiom 18, with possible statuses as *success*, $fail$, *missing*, or *active*.

$$Program \equiv \exists offers.Service \sqcap \exists forProgram^{-}.Outcome \tag{17}$$
$$Outcome \equiv \exists forProgram.Program \sqcap \exists hasOutcome^{-}.Agent \tag{18}$$

3.4. Ranked Goals

Ranking goals allows a cognitive agent to reason about goals in terms of their importance to the agent [3]. A goal state can be preferred over another. If a preference is assigned to a goal it is considered a subclass of the *RankedGoal* class, with a unique ordering relation. A *RankedGoal* is any goal that has an integer preference assigned to it with the $pref$ data property, as defined by Axiom 19. However, goals can be ranked based on one of three order relations.

$$RankedGoal \sqsubseteq Goal \sqcap \exists pref : xsd : integer \tag{19}$$
$$AgentRankedGoal \sqsubseteq RankedGoal \sqcap \exists hasGoal^{-}.Agent \sqcap \exists prefAgent : xsd : integer \tag{20}$$
$$MHRankedGoal \sqsubseteq RankedGoal \sqcap \exists prefMH : xsd : integer \tag{21}$$
$$PracticalRankedGoal \sqsubseteq RankedGoal \sqcap \exists prefPractical : xsd : integer \tag{22}$$

First, during the planning phase, the agent uses their own preferred goal order to calculate the utility of each plan. The agent's preferred ranking is represented by the *AgentRankedGoal* class as defined in Axiom 20. It is a subclass of the intersection between a *RankedGoal*, and a class with both *prefAgent* and *hasGoal* relations. For example, given *Goal* states s_i and s_j along with the assertions $hasGoal(A, s_i)$, $hasGoal(A, s_j)$, $prefAgent(s_i, 1)$, and $prefAgent(s_j, 2)$, the goal state s_i is preferred by agent A over s_j.

During the plan execution phase, Maslow's classical order is used to calculate the utility of goal state as actions to satisfy them are executed. The MH order is represented by the property $prefMH$. A goal ranked by MH is an *MHRankedGoal* class as defined in Axiom 21. It is a subclass of the intersection between a *RankedGoal* and a class with $prefMH$ relation to an integer value. For example, the goal *Food* is an *MHGoal* mapped to the physiological *MHNeed*. The assertion $prefMH(Food, 1)$ would specify that the physiological level *Food* is mapped to is the most important. For each MH level, a specific ranking class that relates prefMH to the type of *MHGoal* it is triggered by:

$$GoalPhysiological \sqsubseteq prefMH:1 \sqcap \exists triggeredBy.MHGoalPhysiological \quad (23a)$$
$$GoalSecurity \sqsubseteq prefMH:2 \sqcap \exists triggeredBy.MHGoalSecurity \quad (23b)$$
$$GoalSocial \sqsubseteq prefMH:3 \sqcap \exists triggeredBy.MHGoalSocial \quad (23c)$$
$$GoalEsteem \sqsubseteq prefMH:4 \sqcap \exists triggeredBy.MHGoalEsteem \quad (23d)$$
$$GoalSelfActualization \sqsubseteq prefMH:5 \sqcap \exists triggeredBy.MHGoalSelfActualization \quad (23e)$$

Finally, the practical ranking of goals represents the order in which goals were satisfied during plan execution. This order is observed in the outcome of a plan following its execution. The data property $prefPractical$ captures this relation, as defined in Axiom 22. The practical rank is captured by logging the execution of a plan. For example, the goals s_i and s_j ranked by agent A above can be satisfied in reverse order. The assertions $prefPractical(s_i, 2)$ and $prefPractical(s_j, 1)$ capture this order.

4. Mapping CHF-HF Data to OSSN

An application of OSSN is to infer the mapping of requests captured by CHF-HF data in using an ontological representation. All recorded requests were combined into 57 basic needs associated with one or more levels of Maslow's hierarchy. A sixth level was added for non-answers like "Don't know". The entire mapping between CHF-HF basic needs and MH levels is provided in [5]. The following sections provide ontological definitions required to map goals directly, conditionally, or to multiple MH levels.

4.1. Mapping Direct Goals In OSSN

Direct-mapping goals are those directly associated with a single MH level. Consider the following OWL examples of clothing and advocacy needs. A request made for an article of clothing is directly mapped to the security level, as defined by Maslow [10], hence a request for clothing is the expressed **goal** and **MH goal** mapped to the security **MH need**. The agent's **motivation** for clothing is simply to "be clothed." The concrete **goal** requested is to get "help with buying or receiving clothing." The **constraint** faced by an agent is "lack of money." The **resource** where an agent can receive information about obtaining clothing without money is a "charity." Finally, the **service** offered by the charity that provides clothing is a "donation centre." As a direct mapping, any goals of type *GoalClothing* are mapped to the same security level. Hence, any *MHGoal* triggered by a *GoalClothing* type is equivalent to a security class, with no other properties required, as per Axiom 24.

$$MHGoalClothing \equiv MHGoalSecurity \sqcap \exists triggeredBy^{-}.GoalClothing \quad (24)$$

4.2. Mapping Conditional Goals In OSSN

Conditional goal-mapping requires some agent specific condition to identify which MH level a requested need is mapped to. Unlike the directly mapped goals for clothing, conditional mappings are inferred from the intersection of an agent's demographic and their specific need. Consider a request for "temporary housing" at some shelter. Such requests are categorized differently for absolutely and relatively homeless clients. For absolutely

homeless it is a physiological **MH need**, while for the relatively homeless it is a security **MH need**. In OSSN an agent's homeless state is a demographic defined by Axioms 12 and 13 for absolutely and relatively homeless respectively. For both types of homeless agents, the **MH goal** is to find "temp housing shelter" **motivated** by wanting "temporary housing for a short time." The requested **goal** is "get help to find temp housing." The **constraint** faced by the agent is not knowing which beds are available and in which shelters. The **resource** is a temporary bed available at a shelter. The **service** is a social worker that provides information about the bed. Mapping the MH goal to an MH level is inferred from the agent's homeless state and goal type, as per Axioms 25 to 29.

$$GoalForAbsHomeless \sqsubseteq \exists hasGoal^{-}.AbsHomelessAgent \tag{25}$$

$$MHGoalTempHousingPhysiological \sqsubseteq MHGoalPhysiological \sqcap \exists triggeredBy^{-}.GoalForAbsHomeless \sqcap \exists triggeredBy^{-}.GoalTempHousing \tag{26}$$

$$MHGoalTempHousingPhysiological \sqsubseteq MHGoalPhysiological \sqcap MHGoalPhysiological \tag{27}$$

$$MHGoalTempHousingSecurity \sqsubseteq MHGoalSecurity \sqcap \exists triggeredBy^{-}.GoalForRelHomeless \sqcap \exists triggeredBy^{-}.GoalTempHousing \tag{28}$$

$$MHGoalTempHousingSecurity \sqsubseteq MHGoalSecurity \tag{29}$$

First, an absolutely homeless goal class *GoalForAbsHomeless* is any goal that is requested by an absolutely homeless agent, as per Axiom 25. Second, a request for temporary housing, say *getTempHousing*2, is asserted as $GoalTempHousing(getTempHousing)$. Mapping this goal to the physiological MH level is conditional on the agent being absolutely homeless as per Axiom 26. The *MHGoalTempHousingPhysiological* class, as per Axiom 27, is also defined as the subclass of *MHGoalPhysiological*. For relatively homeless agents, temp housing goals are mapped to the security level, as per Axiom 28. Similarly to the physiological goal in Axiom 27, the *MHGoalTempHousingSecurity* class is also defined as the subclass of *MHGoalSecurity* in Axiom 29.

4.3. Mapping Unconditional Goals In OSSN

Many OSSN needs are mapped to multiple MH levels at once. For example, doing laundry is mapped to security, social, and esteem MH level needs. Laundry is a request that impacts at multiple MH level **needs**, mainly security, social, and esteem. Each is mapped to the same **MH goal** to "feel safe with others," as per the assertions in Axioms 30 a to c. The **constraint** faced by the agent is that they do not have money to pay for their own laundry. The **resource** is the free laundry facility they can access. Finally, the **service** provider is a shelter that is offering free laundry service.

$$MHGoalLaundrySecurity(feelSafeWithOthers) \tag{30a}$$

$$MHGoalLaundrySocial(feelSafeWithOthers) \tag{30b}$$

$$MHGoalLaundryEsteem(feelSafeWithOthers) \tag{30c}$$

5. Discussion

The OSSN provides an ontological representation of a client's motivations, goals, and different ways goals are ranked. The focus is placed on how the service can relieve constraints exhibited by the agent, which resources are required, and which services provide

those resources. The service provisioning is not centred around service efficiency, but on satisfying the underlying constraints faced by clients. To this end, the CHF-HF dataset captures client needs as they participate in the housing first intervention program. Since needs were collected every three months, the data also captures how a client's needs change over time. By identifying three different goal orderings, changing order of goals and their rankings can be represented and used for goal reasoning by a cognitive agent. Depending on the agent's demographics, OSSN infers how goals should be mapped to Maslow's hierarchy.

Following the ontology engineering method, motivating scenarios proposed in section 2.2 identify the scope and focus for the development of OSSN. Competency questions identify issues that should be addressed and what vocabulary is required to answer them. For lack of space, the complete results and analysis are presented in [5]. Overall, the ontology performs well on questions that relate to client and service types. The relationship between clients and goals is well represented, where SPARQL queries are able to ask and answer questions about demographics and goals. OSSN is also capable of answering queries about service provisioning. By relying on the *Outcome* class, OSSN can answer some queries that relate to the progress participants make in a program. OSSN has several limitations. Any questions with a temporal dimension are not supported by OSSN. For example, the rate at which resources are used or when they become unavailable cannot be answered by OSSN.

6. Related Work

Several ontologies overlap with the proposed ontology and address some of the competency questions. These, however, are service-oriented, focusing on modelling processes and constraints of the service provider rather than the impact on client outcomes. The Open Eligibility Project (OEP) is a taxonomy of service categories offered to clients [1]. The agent is represented by the "human situations" category. It includes age group, citizenship status, criminal history, disabilities, health, household, and urgency. However, each term lacks a definition leaving them open to interpretation. For example, emergencies are simply qualified as "In Crisis," "In Danger," or "Emergency." The GCI ontology focuses on housing and classifies clients as absolutely or relatively homeless [15]. The resources available to the clients are different types of housing. The competency questions GCI addresses focus on details about specific households and aggregate information about city resources and household types. For example, GCI can answer who the individuals in a particular household are and whether that household is considered a "slum household." The INSPIRE ontology captures processes and resources of service providers focusing on elderly and adults living with disabilities [11]. Client needs can be categorized as physical or social, or a combination of the two, along with an urgency indicator. This is used to efficiently identify the appropriate department to transfer a client. The competency questions INSPIRE can answer focus on service assignment. Services and internal workflows are well represented, while client needs and underlying symptoms are not.

7. Conclusion and Future Work

Up to now, the client's perspective of social service policy evaluation has been missing. The work presented here fills this gap by providing an ontological representation

of a client's motivations, goals, and different ways goals are ranked. The Ontology of Social Service Needs (OSSN) identifies the semantic relations between requests made by a client to a service provider, based on data provided by real-life clients about their changing needs while participating in a real intervention program. The ontology provides a goal ranking used by cognitive agents to prioritize goals while planning their actions. The ontology was evaluated by answering certain competency questions. The questions that were not answered are the basis for future work. This involves goal reasoning and planning to simulate a client's interaction with service providers.

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