A Context-aware Component for Identifying Risks associated to Elders' Activities of Daily Living

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Abstract— **As elders age, performing everyday tasks can be filled with risks that threaten their health and independence. We present a context-aware component based on agents that enables developers to build Ambient Intelligence Systems for supporting the independent living of elders. This component uses the ELDeR ontology that we propose to model the context information inherent to the elder's daily activities and that enables agents to infer risks. Our aim is to provide a context-aware component flexible enough to easily enable developers to change the contextual conditions for inferring risks in order to respond to a different scenario. In this paper, we describe the component functionality and illustrate its use by presenting the design of a sample application.**

Keywords-ontology, context-aware, software agents, ambent assited living

I. INTRODUCTION

In order for older adults to live with autonomy in their homes, they need assistance with daily activities in different ways: they may need help to complete an activity; they may need to be warned when facing risks associated with performing an activity; as they suffer from natural cognitive impairment due to ageing, they may forget some events, situations or tasks that impede completing an activity appropriately, so they need to be reminded. A current followed approach for supporting "aging in place" is to integrate the Ambient Intelligence (AmI) vision into the elders' home environment. In this approach, the AmI system should provide facilities to enable older adults to autonomously carry out their daily activities.

For creating AmI systems, not only the pervasive technology that tracks elders' behavior and interaction with household objects is needed [1]. These systems also need context-aware and intelligent systems that monitor the elders' activities of daily living (ADLs) and recognize when they face an abnormal situation or risk. We are following the approach of using agents as a tool for designing and implementing AmI systems [2]. Our context-aware component includes: an ontology for representing context information; and agents that access this ontology for specifying the current elder context and for consulting the contextual conditions that determine if the older adult may need help.

In the following section, we present other works that have used ontologies for representing context information. In Section 3, we describe the ELDeR ontology. In Section 4 is presented the design of the context-aware component. Section 5 presents a sample application designed for illustrated the use of our component. And Section 6 presents our conclusions.

II. RELATED WORK

Several works have proposed infrastructures for facilitating the development of context-aware systems. These works use the ontology-based approach for modeling context information. For instance, SOCAM (Service-Oriented Context-Aware Middleware) includes [3]:

a) A common upper-level ontology for representing the general concepts such as: Person, Location (i.e. OutdoorSpace such as Garden), Computational Entity (i.e. Devices such as TV, Fridge) and Activity (i.e. Dinner, TakingShower)

b) And domain-specific ontologies which define the details of general concepts and their properties in each specific domain. SOCAM already includes an ontology for the smart home domain that specifies general concepts such as: Person, Location, Activity, ScheduleActivity and Device.

Similarly, CoDAMoS provides general ontology-based context models [4]. It provides interrelated sets of extensible ontologies to express contextual information about User, Tasks, Services, Environment and Platform. These ontologies are two-layered context models, which describes contexts both in term of fine grained facts and higher level situations which describe logical conditions.

I.L.S.A is an agent-based architecture for creating home-based systems for assisting elders [5]. To our knowledge, I.L.S.A is the only project that proposes an ontology for this domain: the Consolidated Home Ontology in Protégé (CHOP). This ontology serves two primary purposes. First, it is a common vocabulary for I.L.S.A related concepts, and their relationships. Second, CHOP produces an agent communication interface between I.L.S.A.´s agent-based system components. The ontology includes general concepts, such as Agent (i.e. software or biological agent), Agent_Role (such as Familial and Professional relationships), Communication_Act, Place (i.e. geographical_region, network_address), Process (things that people do in their home, i.e. preparing_food).

The above ontologies are general models (high-level ontologies) for representing context information in different domains. However, creating the lower-level ontologies for specific domains may burden developers. Our aim is to provide a context-aware component that facilitates the building

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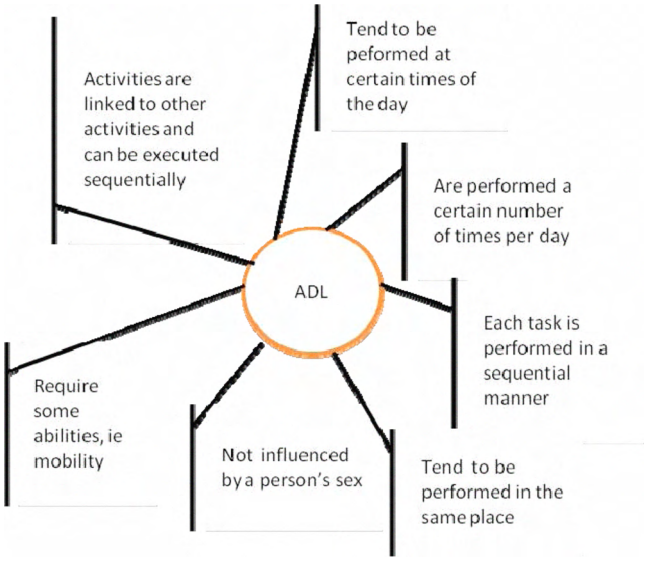

Figure 1. ADL's Characteristics [7]

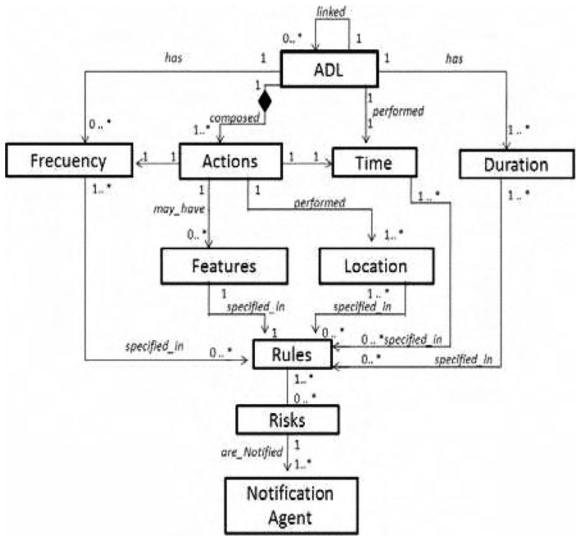

Figure 2. ELDeR Ontology

of AmI systems that support older adults to carry out their activities of daily living at their homes. To reach this end, we are developing the ELDeR(Enabling Living inDependently of Risks) ontology flexible enough to enable developers to easily add and change the contextual conditions for inferring risks [6].

III. ELDER ONTOLOGY

The ELDeR Ontology provides a common language for agents that are involved in the context of elder healthcare. To design the ELDeR Ontology we obtained a general understanding of ADLs from medical literature [7]. Figure 1 presents the ADLs characteristics which were used as a foundation for designing the ELDeR ontology shown in figure 2. Thus, the design of the ontology indicates that activities (**ADL**) are linked to other activities. For instance, some activities are commonly performed sequentially or in a certain order (although not necessarily all the time); for instance: hand washing, eating and teeth-brushing. An ADL is composed of at least one task or **Action**. For example, the hand washing ADL is composed of actions such as open the faucet, take the soap, etc. These Actions will be identified by the programmer according to the pervasive computing infrastructure used for sensing or inferring these actions. An ADL tends to be performed at certain **Times** of the day and with certain **Frequency**. Persons tend to spend certain period of time (**Duration**) for executing it. Each Action can be performed at one or many **Locations,** and at a moment in Time. For example, opening a water faucet may be performed in a bathroom or kitchen at different times during the day. In addition, Actions may have **Features** which we identified as contextual variables of the elder while performing an Action that may cause a **Risk**. These features should be specified in **Rules** that infers risk. For instance the action "open the faucet" is associated with the temperature of the water which is a feature, and the Rule is that if it is 54°C or more there is a Risk of scalding. Thus, as represented in Figure 2, not only Features are specified in the Rules to infer risks but Frequency, Time, Duration and Location may be included in the Rules. For instance: a Rule for predicting if the elder forget to take his medicines should include the Time and Frequency that an elder should take a medication. Risks are linked with **Notification Agents** that notify of the elder's situation appropriately as defined by the application programmer. The identity of these agents should also be specified in the ontology. Thus, the contents of this ontology will be provided by the programmer according to the application scenario being implemented.

IV. AGENT-BASED DESIGN OF THE CONTEXT-AWARE COMPONENT

The context-aware component, illustrated in figure 3, contains agents that provide the characteristics of intelligence and context-awareness required for inferring the elders' activities and predicting if they are facing a risk. These agents were designed based on types of agents proposed in the SALSA middleware [2]. SALA provides a library of classes for implementing and handling the execution model of agents, which consists of the components for perceiving information, reasoning, and acting. The SALSA agents' actions may involve communicating with other agents. For this, SALSA provides a communication protocol that enables agents to interchange different kind of messages. Further information regarding SALSA is found in [2].

As shown in figure 3, the component contains four agents that estimate the following context information: the Time (TimeAgent), Duration (DurationAgent) and Frequency (FrequencyAgent) for performing an ADL. A UserLocation-proxy Agent perceives the elder´s location from an external component that should be created by the application developer. The aforementioned agents communicate the gathered context-information to the Context-Aware Agent. Additionally, developers may identify other context information (Features) relevant for inferring risks. Developers should implement the components for gathering this context information and attached them to the Context-aware component by using the SALSA

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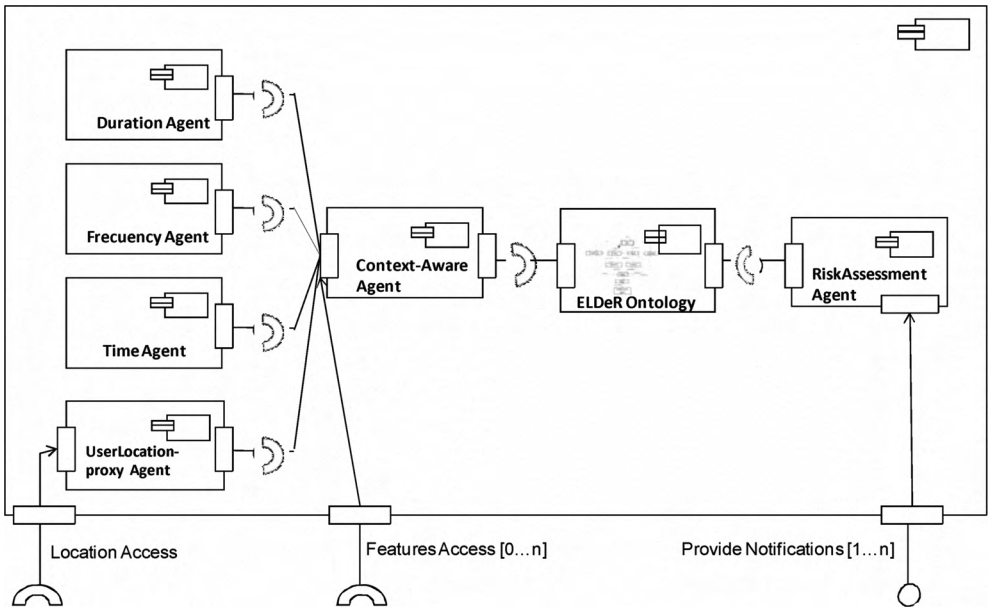

Figure 3. Context-aware Component for inferring risks

communication protocol. The context perceived by the context-aware agent will be used for updating the ELDeR ontology. When the older adult context changes, the Context-aware Agent notifies it to the RiskAssesment Agent, which will consult the ontology to verify if a risk condition has met. The RiskAssesment Agent informs the elder's situation to the appropriate Notification Agent specified by the developer in the ontology. Developers implement the Notification Agent to take the appropriate measures for the Risk such as warning the elder or notifying the elder's caregivers. Notifying Agents are SALSA agents that the programmer creates and that provide notification mechanisms by using appropriate users interfaces for the elders.

V. Sample Application

We illustrate the functionality provided by the context-aware component by presenting a hypothetical scenario of a system that reminds elders to take their medicines.

One key aspect identified in [8] as relevant to address is "supporting everyday cognition", since declines in memory capabilities of elders lead to difficulties in remembering tasks, i.e. taking medication. Older adults that have to take several pills during the day usually tag their medications with the physician indications (doses, time and frequency for taking them); they also assign a special site to place their medications in order to find them easily. An AmI system may support elders in this ADL by:

- Providing reminders before the time for medicating.
- Making older adults aware that the medicine was not taken
- Notifying older adults that the medicine is running out.

The following application scenario illustrates the use of the Context-aware component for implementing an AmI system with the above functionality. The proposed system warns elders by presenting notifications and reminders in a wrist-worn device as presented in figure 4a.

A. *Application Scenario*

The sequence diagram presented in figure 4 illustrates the interaction among the AmI system agents which are the agents of the Context-aware Component and other agents created to provide the desirable system functionality. The following is a usage scenario of the system (see figure 4):

"While Pablo is taking his dinner, the TimeAgent informs the RiskAssesmentAgent that the current Time is 20:45 by sending the SALSA message sendNotification(). Then, the RiskAssesmentAgent consults the ELDeR ontology to get the rules and risks associated with this context information (Time). In this case, "forgetting to take the medicine dicoflenaco" is the possible risk that the elder may face. The RiskAssessmentAgent evaluates the rules and then determines that Pablo has to take 1 pill of dicoflenaco. Finally, the RiskAssesmentAgent informs the MedicineRemindingAgent by sending a sendNotification() SALSA message indicating that the elder needs to take his medication.

VI. Conclusions and Future Work

To facilitate the implementation of AmI systems that support the activities of daily living of older adults, we designed an agent-based component for inferring elders' context and predicting whether they need help to carry out their activities of daily living. With this component we want to facilitate the integration of Ambient Intelligent Systems into the elders' home. For inferring users' context, we have designed the ELDeR Ontology which is a representational model of the elders' context information that is captured by pervasive technology. The ELDeR ontology addresses issues related with the representation of context information, which is

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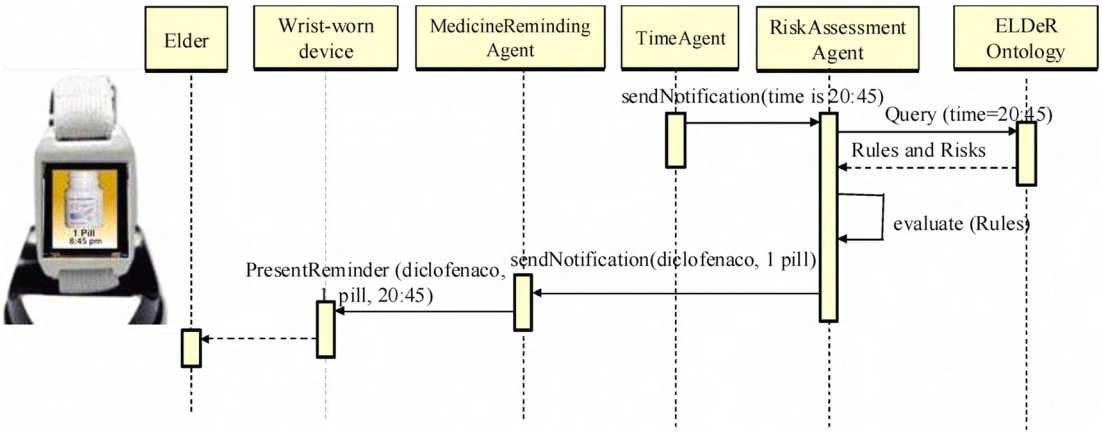

Figure 4. AmI System's agents interacting to remind an older adult to take his medicine

a step towards addressing the inference of abnormal situations faced by older adults. We are designing the ELDeR ontology general enough that it can be used for inferring any risk associated with Activities of Daily Living. We plan to carry out a case study for validating the ontology with older adults and healthcare professionals. And finally, we plan to implement different application scenarios to evaluate the ease of use of the context-aware agent and the flexibility of the ontology for instantiated it according to the scenario supported.

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