A Common-Sense Approach for Automatic Service Composition in Ambient Intelligence

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Abstract. Systems for Ambient Intelligence contexts are expected to exhibit an autonomous and intelligent behavior by understanding and reacting to the activities that take place in such contexts. The work proposed here advocates a common-sense approach as a solution to the shortage of current systems for Ambient Intelligence when dealing with unexpected scenarios.

Keywords: Ambient Intelligence, Common Sense, Planning.

1 Introduction

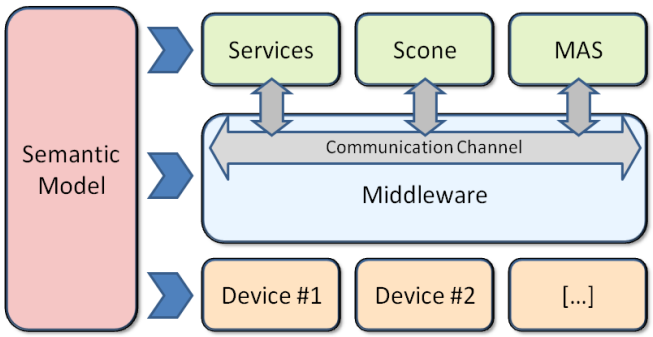
Event management and response generation are two essential aspects of systems for Ambient Intelligence. In spite of having succeed in addressing well-known situations, novel or unexpected scenarios comprise the bottleneck of intelligent systems. Analyzing how people react to these unexpected situations provides an idea about the direction where efforts are to be addressed. Generally, when facing novel situations we tend to establish some similarities with past experiences, or resort to the general knowledge about how things work –the so called common-sense knowledge–, or even look for advice in books. In a human-like fashion, we strongly believe that only systems will be flexible enough to support Ambient Intelligence when common-sense reasoning starts being considered a structural part of such systems.

On the basis of the on-going circumstances and also considering the goals that are to be achieved or fulfilled, Ambient Intelligence systems are expected to devise the behavioral response that will be undertaken by means of available services. Nevertheless, these basic services are not always enough to cope with the complexity of the devised behavior, and therefore, composite services are demanded.

The proposed solution resorts to a common-sense Knowledge-Base with which to both reason about and model the context and the related events. This approach is capable of generating ad-hoc responses, in terms of actions to be performed, by planning course of actions that lead to the composite service that fulfill the sought functionality.

By combining and supporting an action planner on a common sense system, this work proposes an approach to overcome some of the deficiencies of the current approaches to systems for Ambient Intelligence. This work basically joins two long-studied fields, common-sense reasoning and planning, to make them work together towards Ambient Intelligence.

The following figure depicts the overall approach for developing systems for Ambient Intelligence.



2 Leveraging Common Sense

It is apparent that autonomous and self-sufficient behavior needs to be founded on knowledge about how things work (also known as common sense), and on the capability to make decisions based on that knowledge. Automating common-sense reasoning is a task that requires an expressive enough language, a knowledge base where to store such a large amount of knowledge, and a set of mechanisms capable of manipulating this knowledge, so as to infer new information. Regarding the knowledge base, Cyc[1], WordNet[2] and Scone[3] have proof to be successful approaches. The Scone KB project is an open-source knowledge based system, intended to represent symbolic knowledge about the world as an interconnected network made up of node units and links between them. Its principal strength lies in the way in which search and inference are implemented. Scone adopts a marker-passing algorithm [4] devised to be run in the NETL machine.

The approach adopted by Scone better meets the demands of the service composition since knowledge about events and actions are modeled in terms of the context state or world-model just before the action or the event takes place, and the context state immediately after the action [5].

The semantic model proposed in [6] is centered on the concept of a **service**. Under the Ambient Intelligence perspective, services can be decomposed into the set of the **actions** performed on **objects**. These services are offered by **devices**. Adopting

this semantic model has a significant impact on the planning strategy, since we must consider not only the preconditions and effects of actions, but also the objects receiving those actions and the devices providing the services that give rise to actions.

The work in [6] also proposes an approach for action planning with endowed capabilities to handle the non-trivial aspects of common-sense reasoning[1]. The actions that can be performed by a system (**feasible actions**) are determined by the devices and services available at each moment in time. On the contrary those actions that cannot be performed due to the lack of provider services are named here as **non-feasible** actions. Whenever the system demands the execution of a non-feasible action, the planner comes into play. As listed underneath, the `Planning` algorithm starts with an empty plan, the Π plan, to be completed with the list of actions, provided by services. This course of actions are intended to emulate the demanded non-feasible action. The course of actions is provided as a set of actions performed on objects, *A* and *O* respectively, and the results *R* of accomplishing such actions.

2.1 Modeling Multiple-Contexts

The proposed planner exploits the fact that two actions that have similar "**after contexts"** and, therefore similar effects on the context are considered to be functionally equivalent. Moreover, the "**before context"** can be considered as the set of requirements that need to be met for the action to be performed. These two considerations are the cornerstone of proposed planning algorithm.

Representing actions and events in Scone simply consists of defining two new contexts, one describing the world before the action or event takes place and another that represents the state of the world afterwards. The following example describes a simplified definition of the **move** event. Lisa moves can be defined as an specific occurrence of the **move** event.

```
NEW-EVENT move
  :roles
    origin is a place
    destination is a place
    moving-object is a person
  :throughout
    origin differs from destination
  :before
    moving-object is located in origin
  :after
    moving-object is located in destination
```

```
NEW-EVENT-INDV Lisa moves
the origin of Lisa moves is kitchen
the destination of Lisa moves is living-room
the moving-object of Lisa moves is Lisa
IN-CONTEXT before
STATEMENT-TRUE? Lisa is in living-room
  => No
GET the location of Lisa
  => kitchen
IN-CONTEXT after
STATEMENT-TRUE? Lisa is in living-room
  => Yes
```

1 Please, refer to: http://arco.esi.uclm.es/~mariaj.santofimia/ for further information about non-trivial issues of common sense

3 Conclusions

This work points out some relevant aspects that need to be taken into consideration when developing systems for Ambient Intelligence. As an step towards real intelligent systems, this work advocates for a common-sense approach to drive Ambient Intelligence systems in response to on-going situations. To this end, this work proposed a comprehensive solution intended to provide automatic service composition, achieved by means of a common-sense planning strategy.

The comprehensive solution summarized here adopts a three-level approach. It proposes a semantic model for actions and events, which it is considered to be an agreement on how to interpret the knowledge represented in the knowledge base. Furthermore, resorting to a semantic model, to be shared among different instances, is also essential when these instances are expected to extract the same meanings or conclusions from the represented knowledge. It also proposes an action planning strategy so as to make the most of the service functionality. Composite services aggregate the functionality of each of the composing services. Systems for Ambient Intelligence could respond to whatever the needs on the basis of the available services and devices and combinations of those. Finally, this work also proposes a way of capturing the common-sense knowledge that characterized the actions and events by resorting to the semantics of multiple-contexts and possible-words.

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