Diagram Analysis Report: Use Cases for Conviviality and Privacy in Ambient Intelligent Systems

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1 Introduction

The aim of this technical report is to present some use-case scenarios for the Ambient Assisted Living (AAL) domain. These scenarios illustrate how a Home Care System (HCS) could improve its users’ quality of life in a variety of cases. To represent graphically these scenarios, we use the notion of dependencies and dependence networks (DN). Furthermore, we provide some typical Access Control Policies (ACP) that could be applied to these scenarios to guarantee the security of the system and reflect the users’ preferences.

1.1 Ambient Assisted Living

Ambient Intelligence (AmI) represents an emerging field of research and development that is rapidly gaining attention from an increasing number of researchers and practitioners worldwide. The notion of AmI is becoming a de facto key dimension of the emerging Information Society, since many next-generation industrial digital products and services are shifting towards a smart computing environment. AmI promises to enable ubiquitous computing technology to provide a new level of assistance and support to our daily activities.

A prominent example is Ambient Assisted Living (AAL), which aims to address the needs of elderly people and help them maintain independent living, improve their quality of life, participate in social life, and in the same time reduce the costs of health and social care. The significance of this field is demonstrated by the facts that Ageing Well and Independent Living is among the priorities of the FP7 2011 ICT Workprogramme, and that it is the central topic of many European research projects (e.g. AALIANCE\textsuperscript{1}, OASIS\textsuperscript{2}, ePAL\textsuperscript{3}, MIDAS\textsuperscript{4}, ALADDIN\textsuperscript{5}).

1.2 Dependence Networks

In dependence networks, nodes represent agents (humans or not) and arrows represent dependencies; an arrow from agent $a$ to agent $b$, labeled as $g$, can be read as “$a$ depends on $b$, in order to achieve goal $g$”.

Conviviality is a concept from the social sciences, defined by Illich as “individual freedom realized in personal interdependence” (Illich - 1974). Ambient intelligent technology can be used to realize tools for conviviality when we interpret “freedom” as choice (Caire et al. - 2008, 2010). For example, in Scenario 1 (see 2.1), we will see that the system proposes to Annette’s neighbours to suggest other potential helpers if they, themselves, cannot help. We say that there is more choice, and thus it is more convivial.

The focus on dependence networks and more specifically on their cycles, is a reasonable way of formalizing conviviality as something related to the freedom of choice of individuals plus the subsidiary relations –interdependence for task achievement– among

\begin{itemize}
\item [1]http://www.aaliance.eu
\item [2]http://www.oasis-project.eu
\item [4]http://www.midas-project.com
\item [5]http://www.aladdin-project.eu
\end{itemize}
fellow members of a social system. Dashed arrows in the dependence networks of this report, represent the dependencies that, if added, could increase the conviviality of the system. The resulting conviviality is also calculated in Table 1 of the validation section (Section 3).

1.3 Access Control Policies

An access control policy is a set of access control rules that specify the condition under which users are authorized/denied to access the protected data or resources. Positive authorizations refer to permissions to access resources where negative authorizations refer to prohibitions to access resources. In this report, we distinguish between negotiable and non-negotiable authorizations. The non-negotiable authorizations represent the rules that must not be changed since they are necessary to guarantee the security of the system and therefore cannot be modified; the negotiable authorizations are the rules that can be relaxed, for instance, to increase the conviviality of the system.
2 Use Case Scenarios

In this section, we present in details twelve scenarios that we have developed and were validated by the HotCity of Luxembourg.

2.1 Scenario 1: Heart attack 1

Ms. Annette Becker is eighty-five years old. She is prone to heart failures; hence the hospital installed at her house a smart Home Care System (HCS).

Suddenly, as she walks out of the kitchen, she stumbles, falls down and cannot get up. In real time, her health bracelet sends in formation, such that heart beat and skin temperature, to the HCS. The system analyzes the images captured on the video monitoring system and gets an updated medical profile of the patient from the hospital. By combining all the different pieces of information, the system infers that it is a medium emergency situation. In such a case, the emergency calls list specifies Annette’s neighbors as primary contact. The HCS includes a phone communication system, nearby neighbors can receive an SMS on their cell phones inquiring whether they are available to come and help; if not, to suggest a potential friend or family member.

For Annette, being helped by people she feels connected to is important. To this end, each patient is also given an access to social support, such as social assistance and support groups, that he can use to get health-related information and to which he may contribute. However, the system should guarantee that no private information such as video captures or medical data falls in mischievous hands. Therefore, the system should be convivial but stay private.

![Figure 1: The Dependence Network of Scenario 1](image)

2.1.1 Access Control Policy

Negotiable Positive Authorizations

- R1: (Neighbor, manage, Support Resources, permit)
2.2 Scenario 2: Loneliness

HCS arranges a birthday party for a lonely senior citizen

Mr. Frank Kerschen is just going to turn ninety this coming Monday. He feels lonely. He doesn’t expect much from this birthday, nor does he expect many people to remember the occasion: his wife passed away, they didn’t have any children.

On the D-day though, there is a wonderful surprise for Frank: his smart phone, as per his set up, sent messages to his friends to mention Frank’s upcoming birthday. Prior to doing this of course, the smart phone had found the friends’ addresses in Frank’s address book and checked who could be in Frank’s neighborhood – the smart phone had inferred this information by reviewing the information found on each friend on Frank’s calendar.

That Monday, many messages arrived through Frank’s community network, neighbors came by to visit him and were even able to get Frank a common present suggested by Frank’s smart assistant linked to his smart phone.

![Figure 2: The Dependence Network of Scenario 2](image)

2.2.1 Access Control Policy

Negotiable Positive Authorizations

- R1: (Frank, access, Phone Communication System, permit)
- R2: (HCS, manage, Phone Communication System, permit)
- R3: (Community Network, access, Phone Communication System, permit)
2.3 Scenario 3: Isolation

HCS prevents isolation of elderly by encouraging the family to stay in touch

Caroline, Pierre’s grandmother, feels isolated; she hardly hears about her family. Her Home Care System (HCS) records, by getting a notification from Pierre’s brother, who manages the Family Facebook profile, that Pierre is graduating from the University of Luxembourg.

The HCS sends an SMS to Pierre, suggesting him to call Caroline and announce his graduation. Moreover, he has not called her for the past 6 months (the HCS inferred) and she may feel lonely. He agrees that it would be nice and calls her to announce his graduation, and talk to her about his future plans in life. Caroline feels a part of the family now!

![Image](image-url)

**Figure 3: The Dependence Network of Scenario 3**

2.3.1 Access Control Policy

Non Negotiable Positive Authorizations:
- R1: (HCS, manage, Phone communication system, permit)
- R2: (Pierre, access, Phone communication system, permit)
- R3: (Caroline, access, Phone communication system, permit)
- R4: (Pierre’s brother, access, Phone communication system, permit)

Negotiable Positive Authorizations:
- R5: (Pierre’s brother, manage, Family Facebook Profile, permit)
- R6: (Pierre, access, Family Facebook Profile, permit)
- R7: (Caroline, access, Family Facebook Profile, permit)

Non Negotiable Negative Authorizations:
- R8: (HCS, access, Family Facebook Profile, deny)

Two rules are updated after adding the new dependencies:
- R6: (Pierre, manage, Family Facebook Profile, permit)
- R7: (Caroline, manage, Family Facebook Profile, permit)
2.4 Scenario 4: Finances

Financial support from the family and legal support from an expert, arranged by HCS/web

Lukas is 55 years old and recently lost his job. Since then, he has problems paying his rent and bills. His bank agent did not record any salary payment in his bank account this month. The bank agent updated Lukas’s pending bills on Lukas’s Home Care System (HCS).

The HCS asks for Lukas’s permission to call for financial and/or legal help. Lukas responds positively to both and is asked to select the persons that he would prefer to help him among the members of his family or his friends. Lukas selects only his daughter Mary. The HCS also finds Mr Harrison, a local legal advisor, by crawling the web.

Mary receives an email asking for help, explaining the situation, including Mr Harrison’s contact details. Lukas receives an email with Mr Harrison’s contact details too. Mary, with the help of the HCS, arranges a meeting between Lukas, Mr Harrison and herself, to figure out the possible solutions.

![Diagram 4: The Dependence Network of Scenario 4](image)

2.4.1 Access Control Policy

Non Negotiable Authorizations:

- R1: (HCS, access, bank account informations, permit)
- R2: (Lukas, access, bank account informations, permit)
- R3: (Mary, access, bank account informations, deny)
- R4: (Mr Harisson, access, bank account informations, deny)
- R5: (Bank Agent, manage, bank account informations, permit)

Since access bank account dependency requires the following candidate authorization: (Mr Harisson, access, bank account informations, permit) then the dependency is discarded.
2.5 Scenario 5: Fever

A patient with fever does not feel helpless, after talking to his doctor and receiving the right medication

Kenny has stayed home today because of a terrible headache. The Home Care System (HCS) detects that his body temperature is 39°C and that he is at home, when he should be at work, so it suggests calling his doctor, Dr. Eric. Kenny approves this action.

During the call, Dr. Eric asked Kenny to take a fever pill. Kenny uses the HCS to look for the closest pharmacies, in order to get the prescription. He chooses one who knows him and orders the prescription, which is then delivered to him within 30 minutes.

![Figure 5: The Dependence Network of Scenario 5](image)

2.5.1 Access Control Policy

Negotiable Authorizations:

- R1: (HCS, access, bracelet, permit)
- R2: (Dr.Eric, access, bracelet, permit)
- R3: (Pharmacy service, access, prescription, permit)
- R4: (Kenny, access, prescription, permit)
- R5: (HCS, access, prescription, permit)

Non Negotiable Authorizations:

- R6: (Pharmacy service, access, bracelet, deny)

The added dependency has no impact on existing authorizations.
2.6 Scenario 6: Medication

HCS monitors patient to take her medication, and take action if she does not

Susan is 75 years old and her doctor, Dr. James, suggested that it is important to take her medication consistently. However, Susan didn’t take her pills last week.

Her Home Care System (HCS) realized that by monitoring the contents of her medication cabinet. Then, the HCS notified Susan that she forgot her pills, via a voice message.

Yesterday, Susan again did not take her pills. The HCS provided her with convincing video material that she could watch on her TV.

Today, once more, Susan skipped taking her medication and the HCS sends an SMS to Dr. James, letting him know the situation. Dr. James calls Susan and underlines the importance of consistently taking her medication. After the call Susan takes her pills and the HCS sends a confirmation SMS to Dr. James.

![Figure 6: The Dependence Network of Scenario 6](image)

2.6.1 Access Control Policy

Negotiable Authorizations:

- R1: (HCS, access, medication informations, permit)
- R2: (Dr James, access, medication informations, deny)

When the dependency is added then R2 is changed:

- R2: (Dr James, access, medication informations, permit)
2.7 Scenario 7: Weight

Significant weight gain, recognized and solved by HCS

Sam is 67 years old and last week he gained 6 kilos. His Home Care System (HCS) measured his weight when he went to bed and informed Sam about that via his cell phone the following morning. It also asked Sam permission to get medical care. Sam agreed and the HCS crawled the web to find the nearest hospital.

The HCS sent a request to the hospital asking for help. Sam’s problem was depression caused by his retirement; it is good that the HCS got it in time.

![Figure 7: The Dependence Network of Scenario 7](image)

2.7.1 Access Control Policy

Negotiable Authorizations:

- R1: (HCS, access, Sam’s informations, permit)
- R2: (Hospital, access, Sam’s informations, deny)

The potential dependency has impact on R2 which becomes:

- R2: (Hospital, access, Sam’s informations, permit)
2.8 Scenario 8: Depression 1

Depression, expressed through inactivity, is surpassed with the help of WAS

Donald is a 32-year-old salesman at the local shopping center. He works from 8am to 4pm and then he goes straight at home. When at home, he usually watches TV until 9pm and then sleeps until the next morning. These long periods of inactivity and oversleeping is worrying for his health.

It’s now 6pm and Donald is, as usually, watching TV. Donald’s Welfare Assistance System (WAS) has not recorded any physical activities for a long period of time. Therefore the WAS searches Donald’s preferences and personal information.

As a result the WAS suggest to Donald that he should have a walk in the park next to his house, or play his favorite sports, basketball, with his friends Norman, Bob and Stanley. Donald chooses the latter, so the WAS sends an SMS to Bob, Norman and Stanley, asking them if they are available and eager to play basketball with Donald. Unfortunately, Stanley is still at work, so he responds negatively. However, both Norman and Bob call Donald and they arrange a meeting at 7pm just outside the neighborhood’s basketball court.

![Figure 8: The Dependence Network of Scenario 8](image)

2.8.1 Access Control Policy

Non Negotiable Authorizations:

- R1 : (HCS, access, Welfare system, permit)
- R2 : (Bob, access, Welfare system, deny)
- R3 : (Norman, access, Welfare system, deny)
- R4 : (Stan, access, Welfare system, deny)

Potential dependencies have no impact on authorizations.
2.9 Scenario 9: Alzheimer

Alzheimer patient finds his way home thanks to his GPS/video capture/HCS

Joe, an Alzheimer patient, lives alone and he regularly visits his daughter Jane, who lives close by. Today, he left as usual around 2pm. The home video capture recorded his exiting his apartment.

Joe has a smart GPS agent linked to his Home Care System (HCS). The system checks the itinerary of Joe to make sure he does not get lost, and that he takes the best streets.

As it happens, today Joe managed to go straight to Jane. However, yesterday was not as good, as he lost his way. The system then used the voice-activated function of the GPS to navigate him throughout the city streets to reach Jane’s house. This took another hour.

In order to facilitate Joe’s trip, an SMS alert was sent to Jane by the HCS to signal that Joe was 20 minutes away from her house, on Pine street. She was reassured that he is currently walking towards her house.

![Figure 9: The Dependence Network of Scenario 9](image)

2.9.1 Access Control Policy

Non Negotiable Authorizations:

- R1: (Joe, access, Smart GPS System, permit)
- R2: (Jane, access, Smart GPS System, deny)
- R3: (HCS, access, Smart GPS System, permit)
- R4: (Smart GPS Agent, access, Smart GPS System, permit)

The potential dependency has nos impact on authorizations.
2.10 Scenario 10: Depression 2

HCS records lower activity level and contacts a neighbor to visit senior citizen

Max is 80 years old and he has just lost his best friend Nick. Now, he has nobody else to talk to and he is too shy to contact his neighbors. He is on the verge of depression.

Max’s Home Care System (HCS) captured changes in Max’s habits: The door sensor didn’t record any activity (people entering/leaving). The refrigerator monitoring system, indicates empty fridge.

The HCS inferred Nick’s death from the social media; confirmed by the police station and the hospital.

The HCS uses SMSs to inform Max’s neighbors that they should visit him as per their individual agreements when the HCS was installed. Preferred neighbors selected by Max: John, Maria and George receive SMSs, scheduling their visit on Mondays, Wednesdays and Saturdays respectively.

![Figure 10: The Dependence Network of Scenario 10](image)

2.10.1 Access Control Policy

Negotiable Authorizations:

- R1: (HCS, access, refrigerator monitoring, permit)
- R2: (HCS, access, door sensor, permit)
- R3: (Max, access, neighbor’s houses, deny)

After the new dependency is added R3 becomes:

- R3 (Max, access, neighbor’s houses, permit)
2.11 Scenario 11: Alcoholism

Alcoholism prevented by the HCS with the help of the community

Alice is 65 years old. Her Home Care System (HCS) uses a technology that monitors the contents of the refrigerator. It monitored a rapid increase in the consumption of liquors lately.

The HCS warns Alice about health risks of over-consuming alcohol. However, Alice keeps consuming a lot of alcohol the following week. Therefore, the HCS sends an SMS to Alice’s son, Joshua, asking to take action.

Sadly, Joshua is unconcerned and does nothing, so Alice keeps consuming a lot of alcohol. The HCS sends an email to Alcoholics Anonymous (AA), asking for help. AA visit Alice and gradually convince her to quit drinking.

![Figure 11: The Dependence Network of Scenario 11](image)

2.11.1 Access Control Policy

Non Negotiable Authorizations:

- R1: (HCS, access, monitoring system, permit)
- R2: (HCS, access, communication system, permit)
- R3: (AA, access, monitoring system, deny)
- R4: (Joshua, access, monitoring system, deny)
- R5: (AA, access, communication system, deny)
- R6: (Joshua, access, communication system, deny)

The identified dependency has no relation on authorizations.
2.12 Scenario 12: Heart-attack 2

HCS captures patient’s heart attack danger and infers to contact family for help

Dianne is 68 years old and lives alone. In a call with her son John, they argued very roughly. Her Companion Robot (CR) - like robuMATIC project - detects, by face recognition, that Dianne is becoming very pale.

The CR starts a check of her pulse and vital signs. Indeed, Dianne is prone to heart attacks and wears a device at all time, allowing CR to take measurements of heart activities. The Home Care System (HCS), captures the data and infers that Dianne is choked but not in danger of getting a heart attack.

The HCS thus, does not alert the ambulance, but instead, informs John about his mother’s health status by SMS. John feels bad and decides to call back his mom to make her feel better. The HCS also informs Dianne’s best friend Rose, that Dianne may welcome her visit.

![Figure 12: The Dependence Network of Scenario 12](Image)

2.12.1 Access Control Policy

Non Negotiable Authorizations:

- R1: (HCS, access, recognition system, permit)
- R2: (Companion Robot, access, recognition system, permit)
- R3: (John, access, recognition system, deny)

The potential dependency has no impact on authorizations.

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6http://www.aal-domeo.eu/index.php/robots
7http://www.aal-domeo.eu/
3 Validation

The selection of the twelve scenarios presented in this technical report was allowed by the HotCity experts, who ranked each scenario based on the following two criteria:

1. Likelihood, i.e., the probability that the scenario occurs and
2. Impact, i.e., the consequence on human life of the failure of the scenario.

As considered in the approaches of risk based testing, likelihood and impact have been used to prioritize scenarios, from low, value 1, to high, value 3. We compute the priority $P$ of each scenario as the product of likelihood $L$ and impact $I$:

$$P = L \times I.$$  \hspace{1cm} (1)

Table 1 presents the results of this ranking in a descending order in terms of Priority. For each scenario:

- The column “Scenario title” provides a keyword allowing to quickly identify the use-case.
- In the next three columns, are listed the likelihood “L”, impact “I” and priority “P”.
- Column “Conviviality before” lists the number of cycles in the dependence network. Cycles in the network represent that an agent depends on another agent to satisfy its goal; they are identified in the SI* model, using delegation of execution. Cycles in the network are used to evaluate the conviviality of the system.
- Column “Conviviality after” lists the number of cycles in the dependence network, after further dependencies among agents have been identified.
- “Rule Updates” refers to the number of Access Control Rules changed in the policy.

To validate the approach presented in the paper, we systematically seek to increase the conviviality of the system, the maximum conviviality being a clique, i.e., when all agents are connected for all their goals. Of course, as such a system may not be very efficient, a threshold has to be found with the other requirements in order to define the optimal, rather than the maximal, conviviality for the system.

The result of applying our methodology to the twelve scenarios shows that, in the worst case, we can increase the conviviality by eliciting the number of potential distinct coalitions among the agents, up to three and at least by one. We were also able to relax the ACP accordingly.

Consequently, it appears that by just combining the social dimension, i.e., conviviality, and access control policy may bring improvements regarding how users perceive the system. This means that conviviality may easily be improved without degrading the access control policy. The added-value of our approach is to make explicit decisions that were previously taken in an ad-hoc manner.
<table>
<thead>
<tr>
<th>Scenario Title</th>
<th>L</th>
<th>I</th>
<th>$P = L \times I$</th>
<th>Conviviality Before</th>
<th>Conviviality After</th>
<th>Rule Updates</th>
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<td>1</td>
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</tr>
</tbody>
</table>

Table 1: Prioritization of the scenarios based on risk assessment from HotCity Luxembourg. Priority $P$ is measured as the product of Likelihood $L$ and Impact $I$. 
4 Kevoree

The Kevoree project, developed by the Triskell team at the University of Rennes, aims at enabling distributed reconfigurable software development. Build around a component model, Kevoree leverages model@runtime approach to offer tools to build, adapt and synchronize distributed systems.

Figure 13 is a graphical view of Scenario 1 (see 2.1) in the Kevoree model editor of the prototype’s model. The first component instance (BodySensor872) can send a message to the Home Care System (HCS) instance at any time. This message triggers the execution of a sequence as described in the sequence diagram of the paper. The HCS component collects the Personal Health Record (PHR) of Annette, then the list of persons to call using the Emergency Call List (ECL) component.

Once these two information collected, the HCS makes use of a modem to communicate with contacts of the ECL. Finally, a sensor on the door acknowledges the alert.

This model makes a particular configuration of a component-based system that implements the Home Care System described in the report. This configuration can be adapted by changing the instances and the connections of the components to meet, for example, requirements described by one of the other scenarios.

![Figure 13: A graphical view in the Kevoree model editor](image)

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8http://www.kevoree.org/
9http://www.univ-rennes1.fr/