A Way to Personalize In-Home Healthcare and Assisted Living

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Outline

• Introduction
  – Background
  – Challenges
  – Existing Approaches
  – Proposed Approach

• Method
  – System Architecture and main components

• Results
  – Publications

• Conclusion
## Smart Homes (SH)

- Integrate home-based technologies for a **better quality of living of residents** [VanBerlo2002]
  - Enhance **comfort**
    - Automatic lightning and temperature control
  - Increase **safety**
    - Gas leak and fire detection
  - Reduce **costs**
    - Energy management
      - The European Union aims to empower consumers to participate on both saving energy and producing energy
Ambient Assisted Living (AAL)

- Utilizes the pervasive infrastructure of smart homes to enable *age in place* and *support caregiving* (formal and informal)
  - The main driving force for the growing interest towards AAL systems is the *rising costs of healthcare*
    - Growing aging population
    - Increased demand of homecare services
  - Enhance well-being, independence and medical care
  - Avoid early institutionalization
  - Self-care and “Patient empowerment” [Bos2008]
Categorizing users, services, and technologies within Smart Home and Ambient Assisted Living systems

- Smart homes are attractive to people while they are young and supportive of them as they age
- Smart homes also support those delivering care
SH and AAL systems are complex to build, use and maintain

- **Diversity**
  - Evolving individual needs and preferences
  - Device heterogeneity
  - Home environments are also different and very dynamic
  - Single vs. Multiple residents

- **Privacy and Security Issues**
  - Sensitive data
    - What data are going to be shared and who will have access to the data?

- **Trust**
  - Reliability

- **Personalization**
Existing SH and AAL projects

– Aware Home, Tiger Place, GatorTech, PlaceLab, ORCATECH, CASAS, ...
– MonAMI, Persona, Oasis, Soprano, UniversAAL, ...

• There is no common standard for intercommunicating and integrating devices and applications
• There is no widely adopted architecture for these systems
• Personalization mostly in terms of presentation of information
• Database Management Systems
  – Under-utilized, used exclusively for data storage

• But, Database Management System can do more!
Database-centric architecture

• Database Management Systems (DBMS)
  – Database: organized collection of data
    • Data is organized and stored in a way that facilitates data retrieval
  – Mature technologies
    • Provide other mechanisms than data storage that can be utilized to address important requirements in SH and AAL systems
      • Security
      • Privacy
      • Dependability (Reliability and Maintainability)
      • Adaptability (Personalization)
      • Scalability
Data storage is the most important functionality in continuous, long-term home-based healthcare systems

• Provides accurate and reliable data
  – Learn about individuals (normal behavior)
  – Support “patient empowerment” [Bos2008]
  – Better decision making
  – Better understanding of aging and illnesses
  – Prevention and management of chronic diseases
  – Conservation of healthcare resources
  – Data analysis methods that can reveal patterns or unknown relationships that describe, for example, the onset of a health problem
Mechanisms supported by DBMSs

• Data Management
  – Allows users to control which information is shared (privacy)

• Extensibility
  – Allows data processing to be performed within the DBMS (security)
  – Functionalities tailored to user needs (personalization and adaptation)

• Authentication and Access Permissions (Roles)
  – Allow users to define who can access the shared information (security)

• Trust
  – Availability, reliability and maintainability
• **Active Database**
  – Contains the model and the logic to describe and control the environment
  – Facilitates **adaptation** of implemented functionalities, consequently **personalization**

• **Resource adapters**
  – Facilitate the **integration** and **interoperation** of heterogeneous hardware and software technologies
A “Smart Bedroom” as an Active Database System

- 9th Int. Conf. on Intelligent Environments (IE'13)
- Proposes a database-centric architecture for smart environments
- A novel approach to architect smart environments as an Active Database
- The feasibility of the approach is demonstrated with a “Smart Bedroom”
- Best Doctoral Colloquium Award
A Database-Centric Architecture for Home-Based Health Monitoring

- Int. Work-Conf. on Ambient Assisted Living (IWAAL 2013)
- Exploits the event-driven mechanisms supported by databases to detect and respond to events taking place in the home within the DBMS itself (bed-entrances and exits, motion sensors, door openings)
- Explores database extensions to model early night behavior
  - In collaboration with Jens Lunström – CAISR – ISLab
- Argues that such an approach leads to better performance and increased security and privacy, while facilitating the adaptability and scalability of AAL systems
- Evaluates the approach with real data ("Trygg om natten" dataset)
Databases provide mechanisms that can be utilized to address important requirements for security, privacy, trust, personalization, and scalability in Smart Homes and Ambient Assisted Living systems.

These mechanisms are not fully exploited in current Smart Home and Ambient Assisted Living infrastructures.

**Database-centric architecture**
- Facilitates personalization and scalability of the system as individual needs and preferences evolve
- Functionalities are implemented within the database itself
  - Better performance
- The database resides in the home
  - Reduced data communication
  - Increased security and privacy
Thank you!
Host PC

011010

Storage

0234 0045 0015 0052

Database

API

UDFs

Active Database

Active Rule

Trigger

IPC

0036 0042 0008

Resource Adapters

ADC
• **Active Database**
  – Contains the model and the logic that describe and control the environment

• **Resource adapters**
  – Integrate hardware and software technologies
• Software components to abstract heterogeneous hardware and software technologies
  – Facilitate technology integration and interoperation

• Few responsibilities
  – Robust and reliable

• Gateway between the environment and the database
  – Stream data acquired by sensors to the database
  – Control actuators in response to commands received from the database
  – Provide user input and output

• Can be implemented in different programming languages
• **Storage**
  – Contains the model that describes the environment

• **Active Rules**
  – To monitor and react to circumstances of relevance

• **Database Interface**
  – Contains the model and the logic that control the environment
  – Exposes data access and manipulation
    • Increased security
  – Contains the implemented functionalities
    • Facilitates adaptation, consequently personalization

• **Database Extensions**
  – In-database processing