SMART FURNITURE AND ITS APPLICATIONS IN AAL

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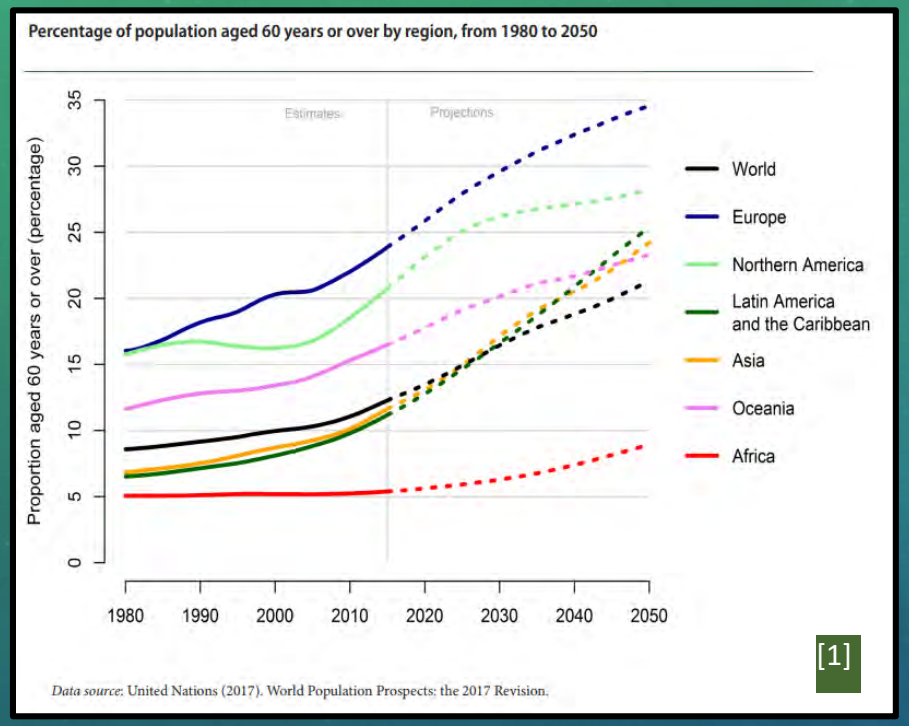
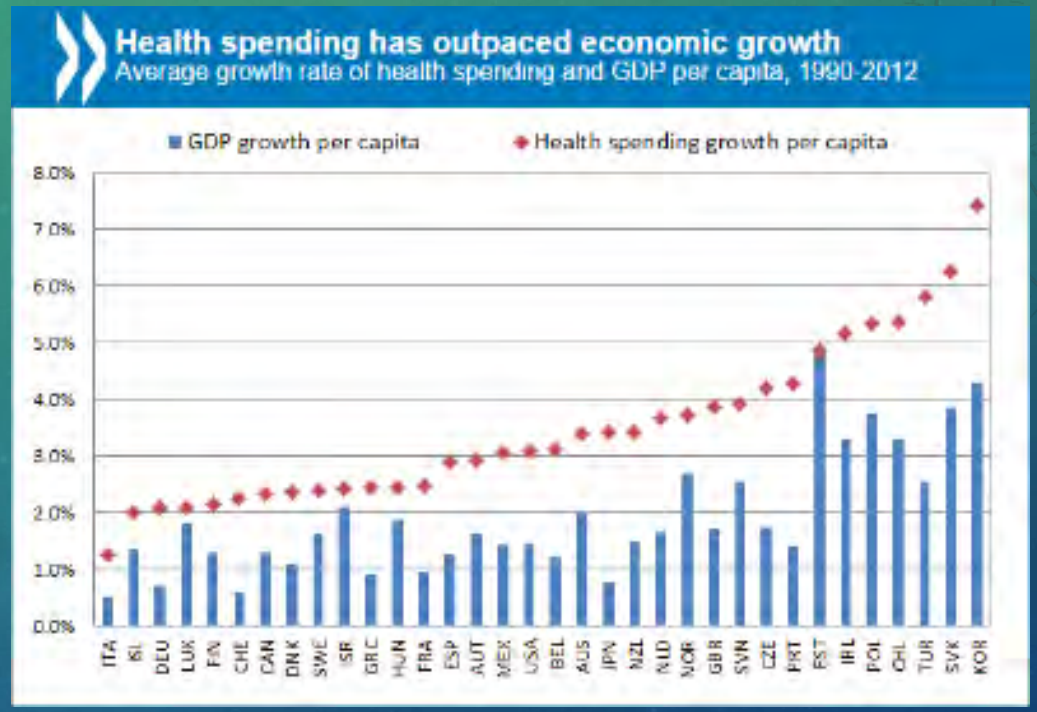
Outline

- Ageing ➔ Demographics & healthcare costs
- Solutions: AAL and AHA
- Smart Furniture Features
- Smart Furniture in AAL
- Commercial products
- Smart furniture examples based on: WSN and IoT
- Conclusions

Ageing ➔ Demographics & healthcare costs





- Ratio “people>65” to “people 15-64” in EU: 28% (2015) ➔ 50% (2060) [2]
- Dementia [2]
  - 6% of the EU population >60
  - Alzheimer’s accounts for 65% of all cases. Probability doubles every 6 years

[1]. “World Population Ageing,” United Nations. http://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2017_Highlights.pdf (accessed on 05/03/2019)
[2]. “AAL Market and Investment Report,” Technologpis Group. https://drive.google.com/file/d/1Yh1JX4pZ2rVdZNN6D40Z9_8ahD3ntDzo/view (accessed on 05/03/2018)

Solutions: AAL and AHA

European Innovation Partnership (EIP) on AHA

- Both concepts aim to promote **healthy ageing and quality of life** for older adults
- Originally **Ambient** Assisted Living (first EU call in 2008)
  - Device-oriented
  - Focused on **physical activities**
- Evolved towards **Active** and Assisted Living (2014 EU call)
  - User-oriented, improvement of QOL (Quality of Life) and overall health (mental and physical)
  - Use of ICT to enable individuals to live an active, socially involved and independent life
- AHA (Active and Healthy Ageing) as defined by WHO:
  - "Active ageing is the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age" [3]
- AAL is technology-based, whereas AHA open to any solution

[3]. "Active Ageing A Policy Framework," World Health Organization. https://extranet.who.int/agefriendlyworld/wp-content/uploads/2014/06/WHO-Active-Ageing-Framework.pdf (accessed on 05/03/2019)

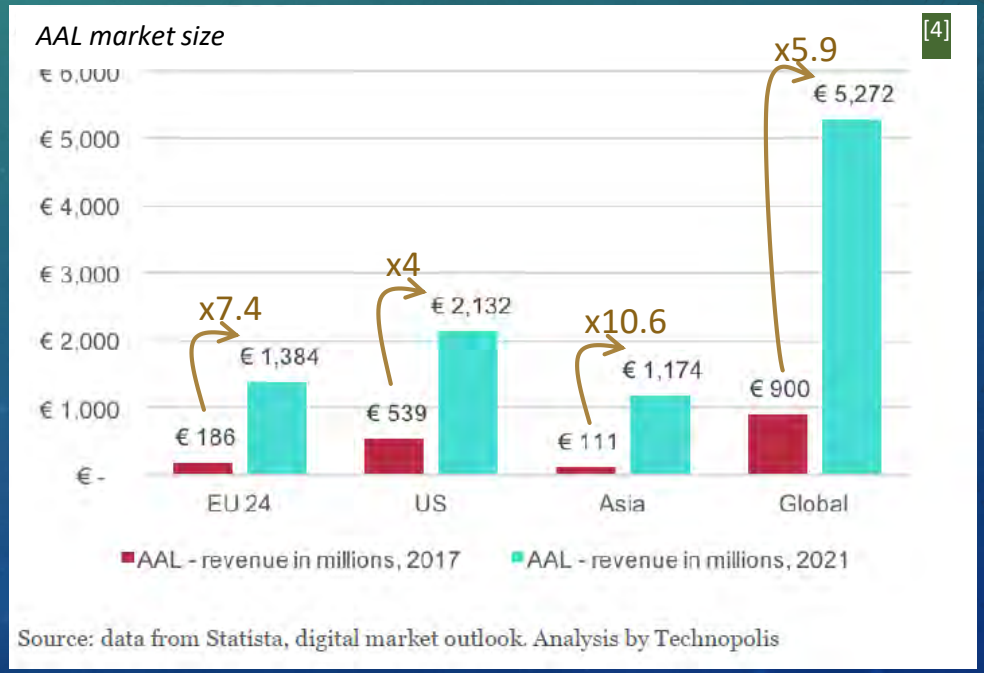
AAL drivers and barriers

DRIVERS

- **Growing political awareness:**
  - ➔ Maximizing 'efficiency'
  - ➔ Connected healthcare through IoT and other tech.
- **Increased consumer interest and awareness** through the popularity of mobile phones apps and wearable devices (e.g. "Quantified Self")
- **Increasing penetration of technology**:
  - Older people are quickly adopting usage of internet, smartphone and wearable tech, even telecare
  - Increase of ICT in health and care systems
- **More and better technologies** can be integrated and provide better services
  - E.g. remote patient monitoring through LPWAN

BARRIERS

- Privacy and security concerns ➔ GDPR
- Technical skills: 32% of 55-75-year-olds had at least basic digital skills
- Interoperability ➔ standardization acceptance is needed (e.g. universAAL)
- Market fragmentation: many SMEs have their own proprietary solutions



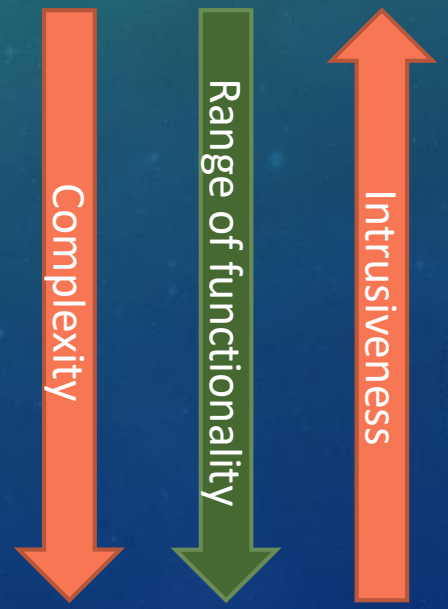
[4]. "AAL Market and Investment Report," Technologpis Group. https://drive.google.com/file/d/1Yh1JX4pZ2rVdZNN6D40Z9_8ahD3ntDzo/view (accessed on 05/03/2019)

Smart Furniture Features

- Traditional furniture is and will always be
  - Key part of our lives and our everyday environment (home, office…)
  - Close to us *anytime and anywhere*
  - We interact with furniture ➔ touch it, sit on it, lie on it, write/work on it…
- Smart Furniture ➔ integrates technology so
  - It can be hidden and our perceived environment looks unaltered ➔ **non-intrusive**, technology adapts to us
  - It can be anywhere ➔ **pervasive**
  - It can follow our actions ➔ **behavioural detection**, sleep tracking, habits, accidents…
  - It can even touch us ➔ **accurate** measurements, great for **health monitoring**
  - Furniture itself **can even adapt to our needs through actuators**

Smart Furniture in AAL

- Smart furniture complements other approaches such as wearable devices and ambient sensors
- Ideal for **health and behavioural monitoring** since it can be used to determine mental and physical health, as well as accidents/emergencies ➔ **Many applications in AAL**
- Possible approaches
  - Furniture addon or accessory
    - Limited and non-integrated design, requires user intervention, more intrusive…
    - Can be added to existing furniture ➔ lower cost
  - Stand-alone smart furniture
    - limited scope and functionality
    - can be developed independently, lowest complexity
  - Part of a bigger AAL system
    - Widest scope and range of functionalities
    - Limitations in design and development, higher complexity



Commercial products

- Almost no smart furniture products devoted for the AAL market. **Reason: complexity**
- Most smart furniture products target the **general market**, e.g. smart mattress for sleep tracking
- Many add-ons for furniture in AAL domain:

Anti-wander alarms

MIRAY

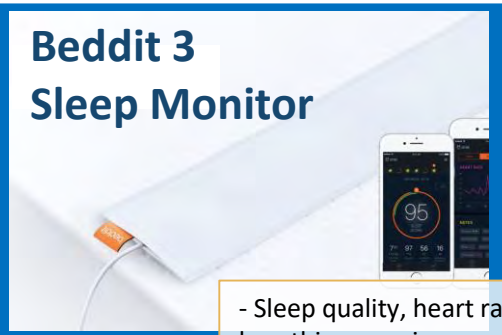
- Sensor under the mattress
- Bed Leaving Alarm
- Nurse is warned wirelessly

Sleep trackers

Withings Sleep Tracking Mat

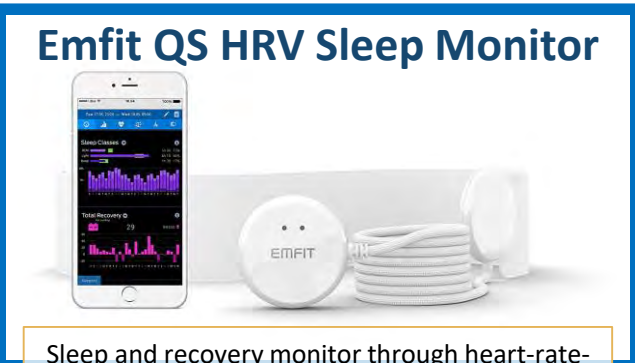
- Sleep cycles, heart rate and snoring.
- Coaching APP
- Control smart home devices (in/out of bed)

Beddit 3 Sleep Monitor



- Sleep quality, heart rate, breathing, snoring, environment.
- APP

Emfit QS HRV Sleep Monitor



Sleep and recovery monitor through heart-rate-variability for recovery and readiness analysis

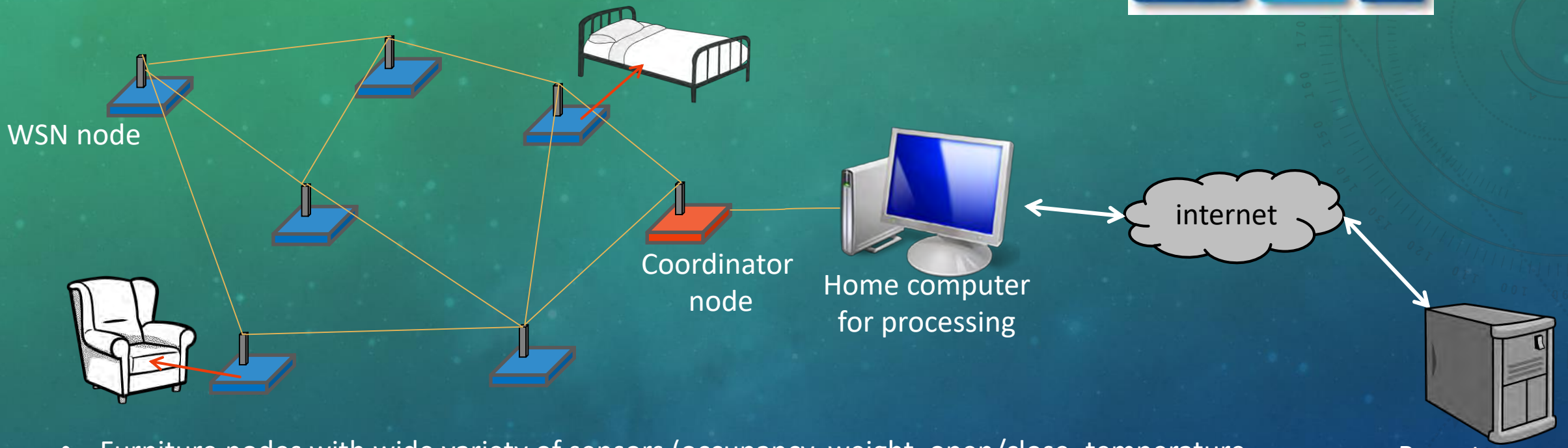
MSI Project: Intelligent Sensing Furniture [5]

- Goal: To improve the accuracy of AmI systems for elderly care in a non-intrusive and seamless way, along with furniture actuators
- Design and development of
  - WSN with very wide range of sensors
  - Artificial Intelligence SW for autonomous learning of user behaviour and alarm generation
- Integration of WSN nodes in furniture
- Furniture prototypes and pilot trials
- Issued patent in force with CETEM as leading applicant

Financed by: plan avanza2 GOBIERNO DE ESPAÑA MINISTERIO DE INDUSTRIA, TURISMO Y COMERCIO

[5]. http://www.cetem.es/proyectos/i/774/321/proyecto-msi-finalizado (accessed on 05/03/2019)

MSI Project: Intelligent Sensing Furniture

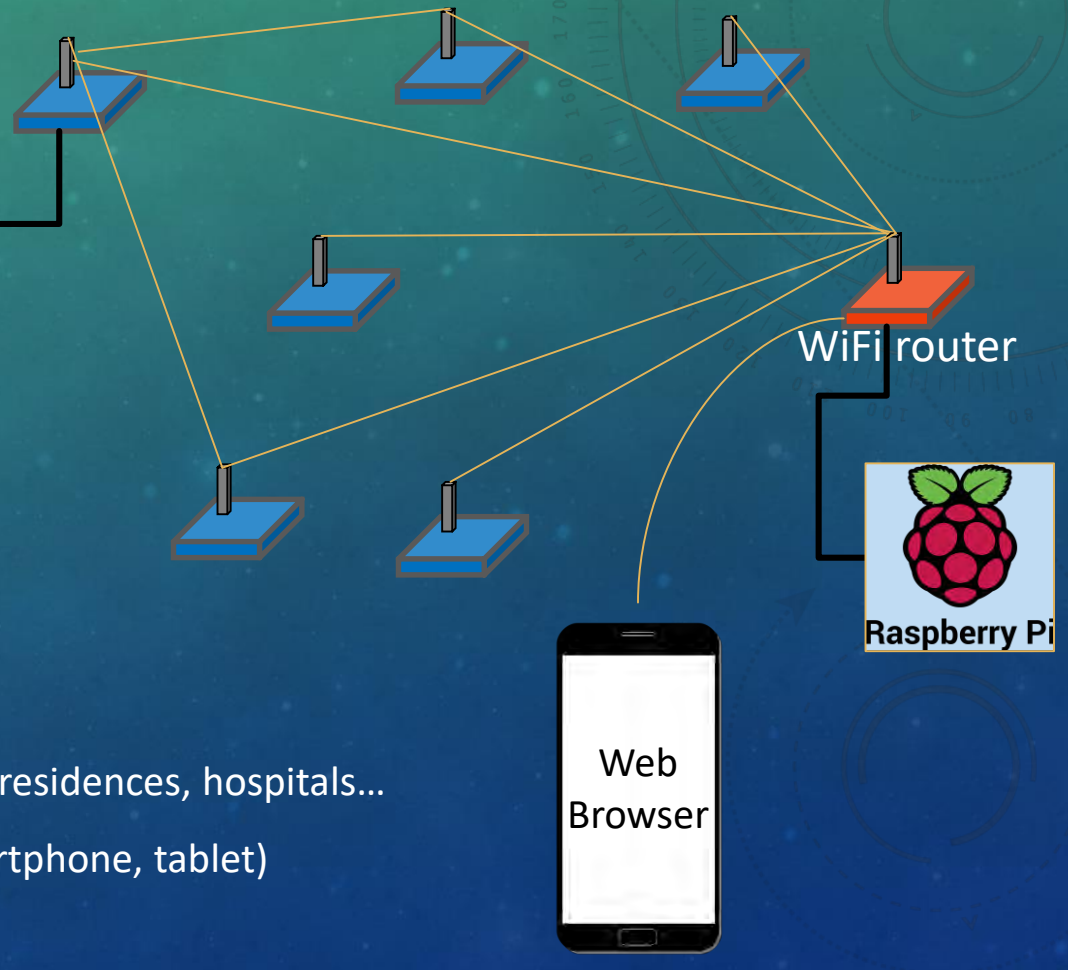


- Furniture nodes with wide variety of sensors (occupancy, weight, open/close, temperature, humidity, …)
- Ambient nodes (IR movement, temperature, humidity) distributed across the home
- Expertise requires multiple partners: HW, SW and AmI, as well as furniture design

Too complicated → MSI evolved into a much simpler product

AmICare: Ambient Intelligence for Supporting Caregivers [6]

Project developed by CETEM



- Each node is made of:
  - 1 electronic PCB in a box
  - 1 USB power adapter
  - 1 textile sensor

Main advantages:

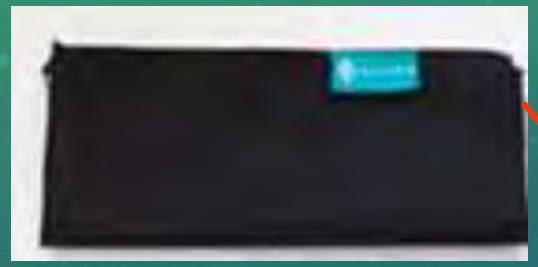
- Uses existing WiFi network
- Ease of deployment and maintenance ➔ low cost of ownership
- No need for wearable devices
- Scalable ➔ good for big caregiving facilities such as nursing homes, residences, hospitals…
- Configured and accessed with internet-capable device (e.g. PC, smartphone, tablet)

Practical issues with WiFi range and interferences

[6]. Bleda, A. L., Maestre, R., Beteta, M. A., & Vidal, J. A. (2018, October). AmICare: Ambient Intelligent and Assistive System for Caregivers Support. In 2018 IEEE 16th International Conference on Embedded and Ubiquitous Computing (EUC) (pp. 66-73). IEEE.

Asistae: an AAL product for the peace of mind [7]

Textile sensor for armchair and bed



Communication (GSM) and processing box

wire

IoT-based solution

Product designed independently, later integrated

Cloud

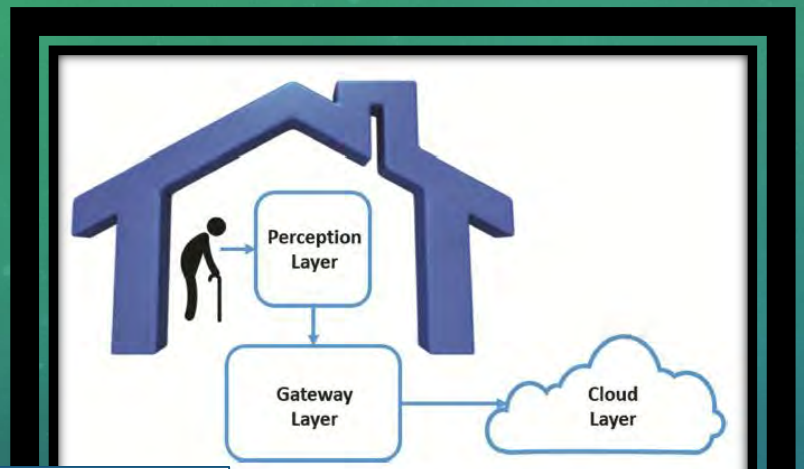
- System directly communicates changes to cloud
- No need for existing infrastructure such as WiFi
- Smartphone app
  - Can be configured with timing-based alert rules
    - Ex1: if user has not seated by 10:00 am
    - Ex2: if user is still seated by midnight
  - Represents occupancy during the last days

[7]. http://asistae.fama.es/ (accessed on 05/03/2019)

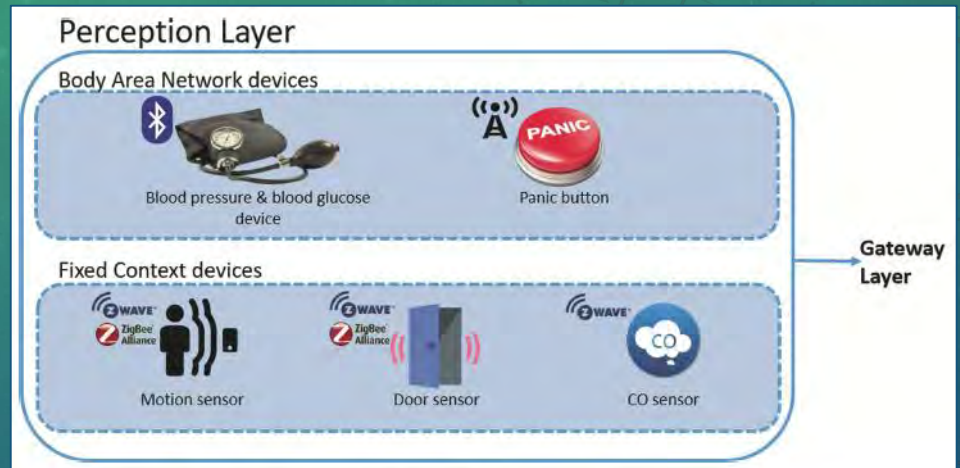
A product by fama

With the collaboration of CETEM

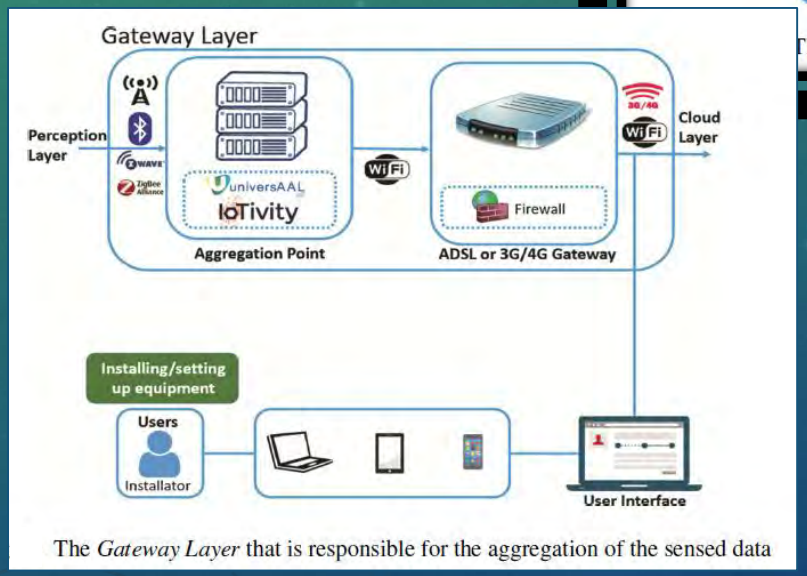
IoT-based AAL example: ACTIVAGE Greek pilot [8]



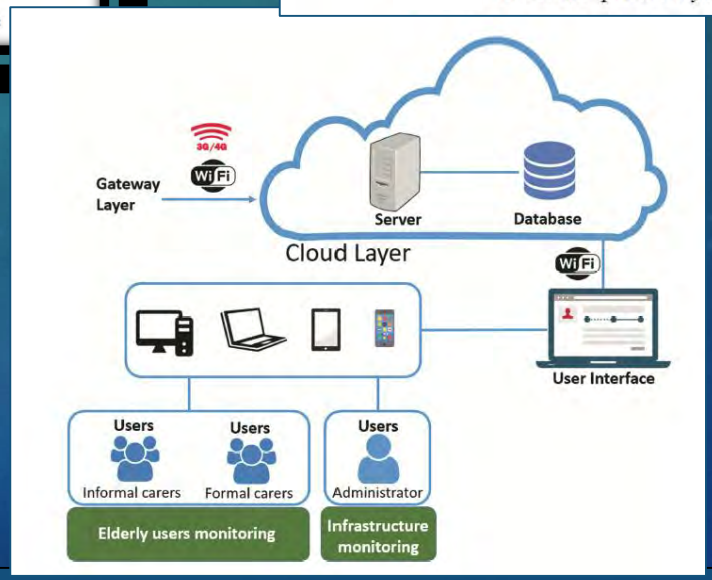
The adopted three-layered system architecture



The *Perception Layer* that contains all integrated devices

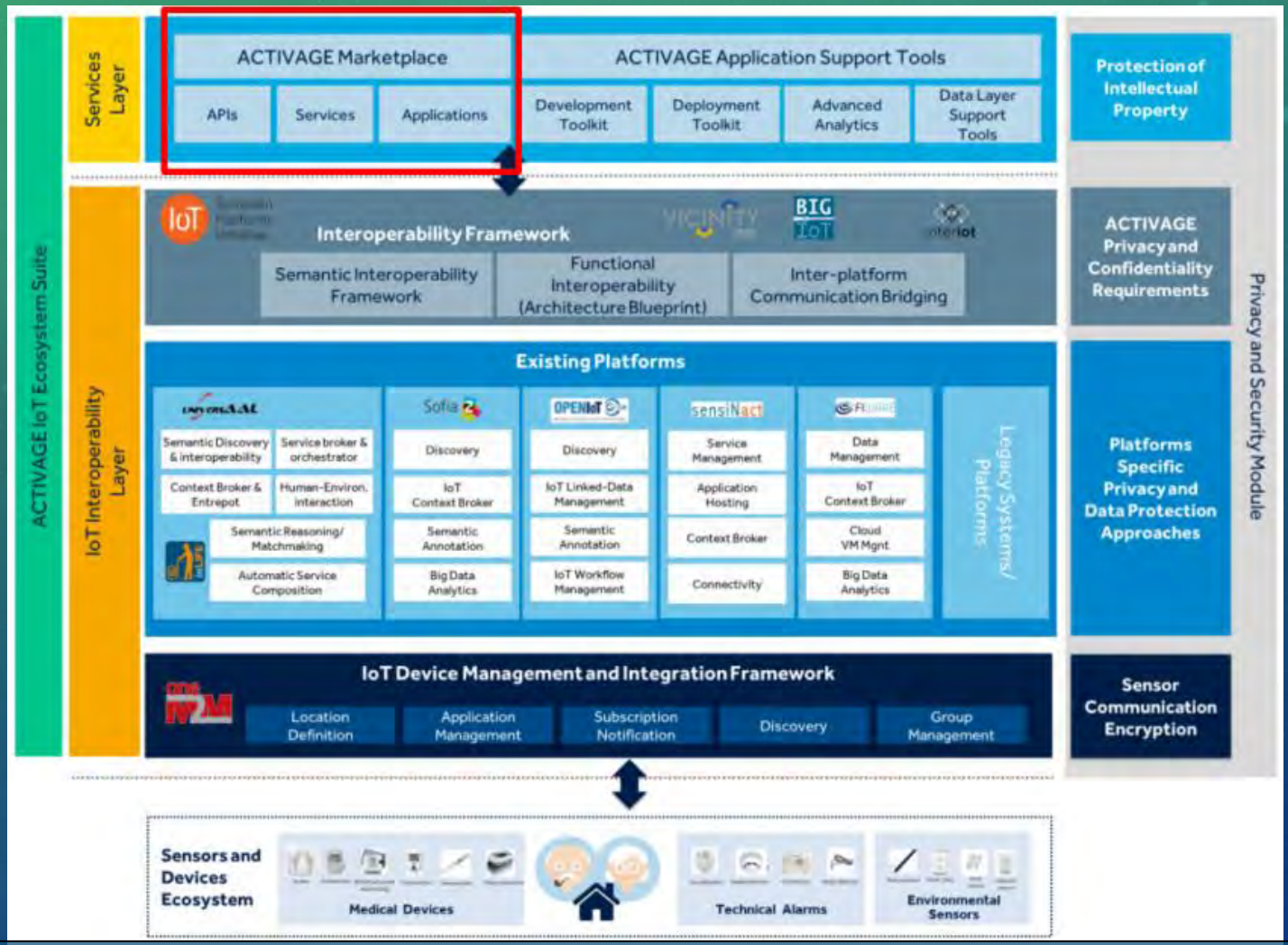


The *Gateway Layer* that is responsible for the aggregation of the sensed data



[8]. Stavrotheodoros, S., Kaklanis, N., Votis, K., & Tzovaras, D. (2018, May). A Smart-Home IoT Infrastructure for the Support of Independent Living of Older Adults. In IFIP International Conference on Artificial Intelligence Applications and Innovations(pp. 238-249). Springer, Cham

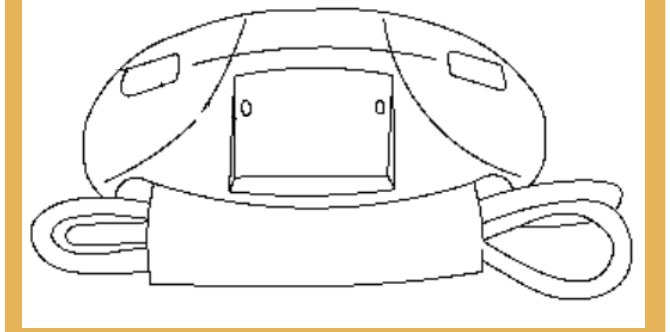
ACTIVAGE overall architecture [9]



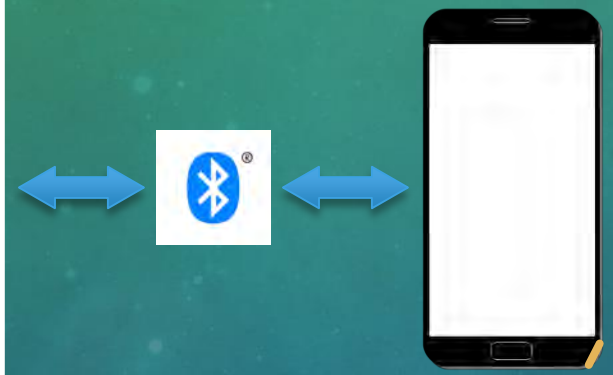
[9]. https://iotweek.blob.core.windows.net/slides2018/05.06.2018./Kaklanis_Votis_ACTIVAGE_Marketplace.pdf (accessed on 05/03/2019)

VitalMob: an IoT-based telecare Project

ECG and blood pressure portable device



Project developed with the participation of CETEM, RGB Medical Devices and others



Remote server with processing algorithms

Alerts

HMI

Robotic Furniture by Ori

- Ori is a spinout of MIT Media Lab spinout
- Smart robotic furniture goal is to optimize space in small apartments
- Ori's robotic furniture can transforms into: a bedroom, working or storage area, large closet, or slides back against the wall
- Video in: https://youtu.be/tTXu00ywQ_I

https://oriliving.com/ori-studio-suite

Conclusions

- AAL ➔ **Active** and Assisted Living: ICT for active, socially involved and independent life
  - Intersection of telecare, telehealth and smart home for older adults
- Sustainable solution for aging societies requires other approaches ➔ AAL
- AAL drivers are growing quickly: demographics, care costs, consumer interest and awareness, penetration of technology, better technologies brings along better services
- The global market of AAL is estimated to grow exponentially
- Smart Furniture – three approaches (ordered in growing complexity and cost):
  - Addon to existing furniture
  - Stand-alone smart furniture
  - Part of a bigger AAL system
- AAL architectures:
  - WSN with local processing was first comm solution with limitations
  - IoT-based AAL with open platforms provide widest range of possibilities, and simplifies the creation of Smart Furniture
- Still the standardisation of AAL platform remains an open issue