Ambient Assisted Living:
Towards Solving the Aging Society Problem

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Fraunhofer Verbund
Informations- und
Kommunikationstechnik

Outline

- **Motivation**
    - **Societal trends**
    - **Technological trends**
    - **Vision: Ambient Intelligence (AmI) Systems**
    - **Challenges**
- **Fraunhofer Organization**
    - **ICT Group**
    - **AmI Research**
- **Health Sector**
    - **Overview**
    - **Project Example: AA Emergency System**
- **Summary**

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Motivation

ICT support for longer independent living at acceptable cost!

- **<u>Societal Trends</u>**

  - **Aging society**

    · **Human life expectancy continues to rise**

      - **Portion of life after work increases**

      - **Portion of „dependent" life after work increaes also?**

    · **Costs for living (incl. health care) are sky-rocketing**

  - **Information & ICT services available anywhere & anytime**

    · **Services will come to the customer (internet of services)**

    · **Enables increasing mobility**

  - **Energy crisis**

    · **Large ICT systems require increasing amounts of energy**

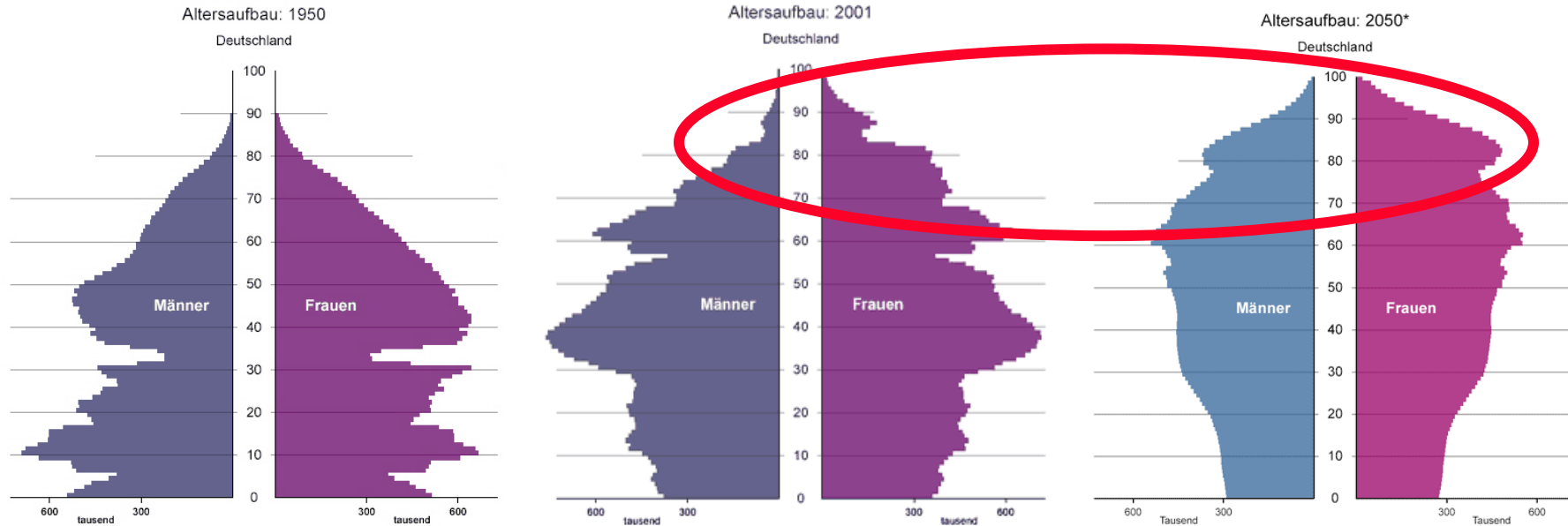   · **Moore's law suggests no limits to growth; energy may!**
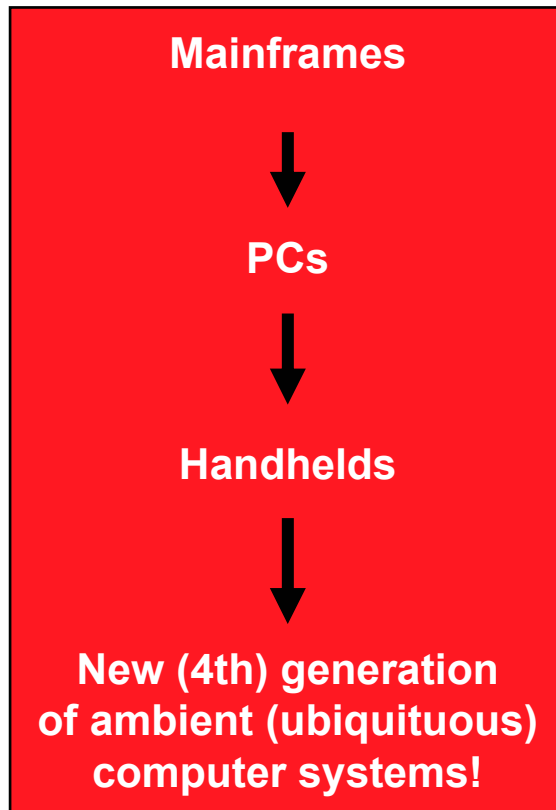
Demographic Trend

Source: Statistisches Bundesamt, BMGS, DIW

- **People in Germany above age 70**
- **2006: 10 Million**
- **2040: 18 Million**

Motivation

- **Technological Trends**

<table>
<tr><td rowspan="9" style="background:red;color:white">**Mainframes**

↓

PCs

↓

Handhelds

↓

**New (4th) generation
of ambient (ubiquituous)
computer systems!**</td></tr>
</table>

- **Microelectronics**
  - **Ever smaller sensors & computers/processors**
  - **Focus on energy efficiency**
  - **„Wearable computers"**
- **Secure communication technology**
  - **Multitide of communication technologies (LAN .. Broadband)**
  - **Access to information & services from any location**
- **Ambient technology**
  - **„Invisible" sensors & computers - hidden in the environment, networked**
  - **„Anticipate the user's needs"**

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Motivation

- ### <u>Vision (Ambient Intelligence Systems)</u>

    - **Invisible, pro-active (= AmI) computer support**   ▶

    - **Affecting living at home**
        - **Emergency support (e.g., detection of burning stove)**
        - **Health support (e.g., detection of fallen, unconscious individuals)**
        - **Assistance (e.g., support for cooking of vision-impaired people)**
        - **Comfort support (e.g., personalized infotainment)**
        - **…**

Characteristics of Ambient Intelligence (AmI) Systems

Many application areas:

- **automobiles, traffic control**
- **logistics**
- **health care**
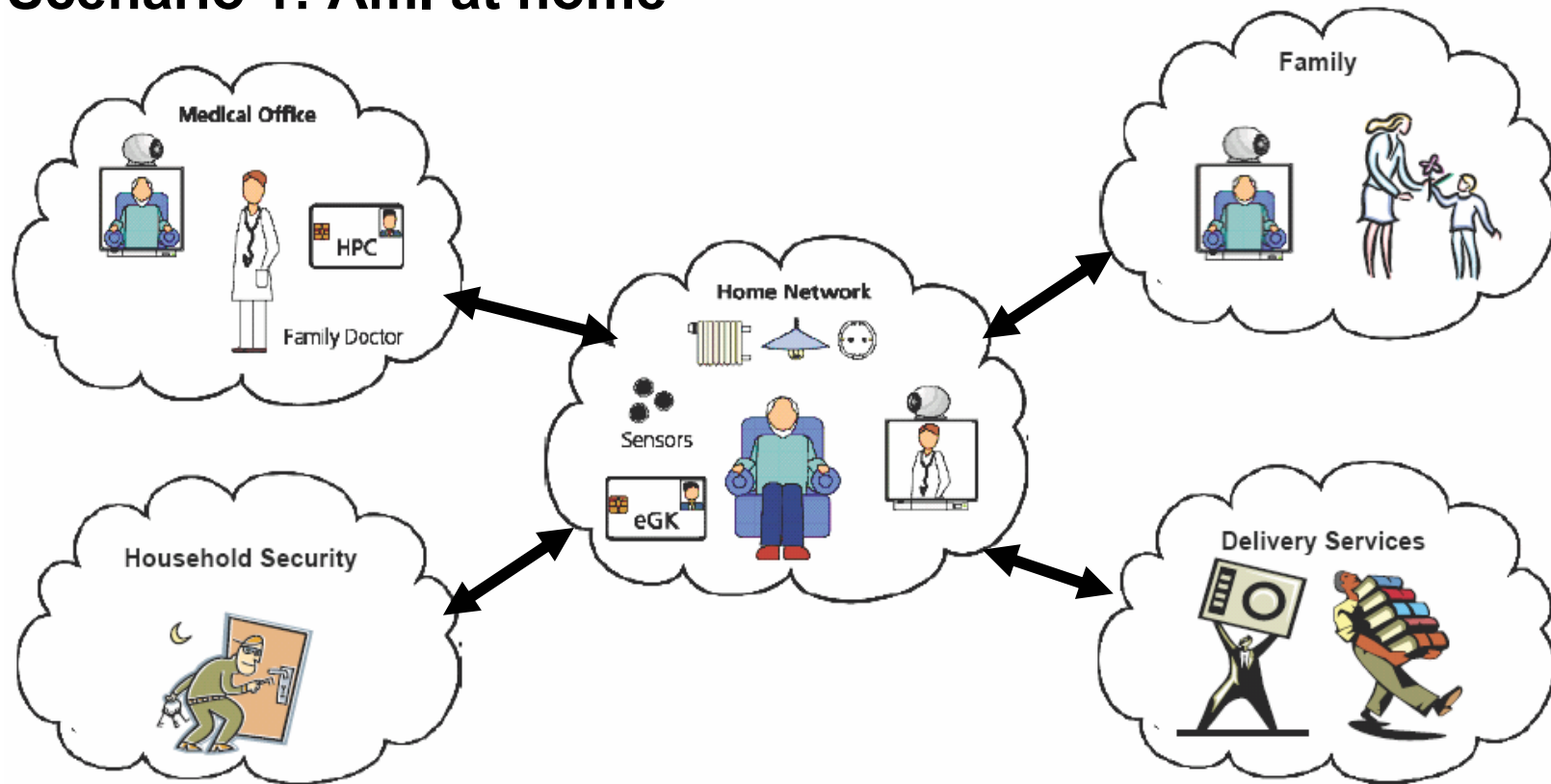- **facility maintenance**
- **etc.**

- **Invisible (embedded in the environment)**
- **Mobile**
- **Context aware**
  - **via attached sensors**
  - **via ad-hoc wireless networking**
- **Humanoid**
  - **interaction with humans by voice, gestures and visual animation**
- **Anticipatory**
  - **pro-active operation**
- **Adaptive**
  - **self-configuring**
  - **self-healing**
  - **self-organizing**
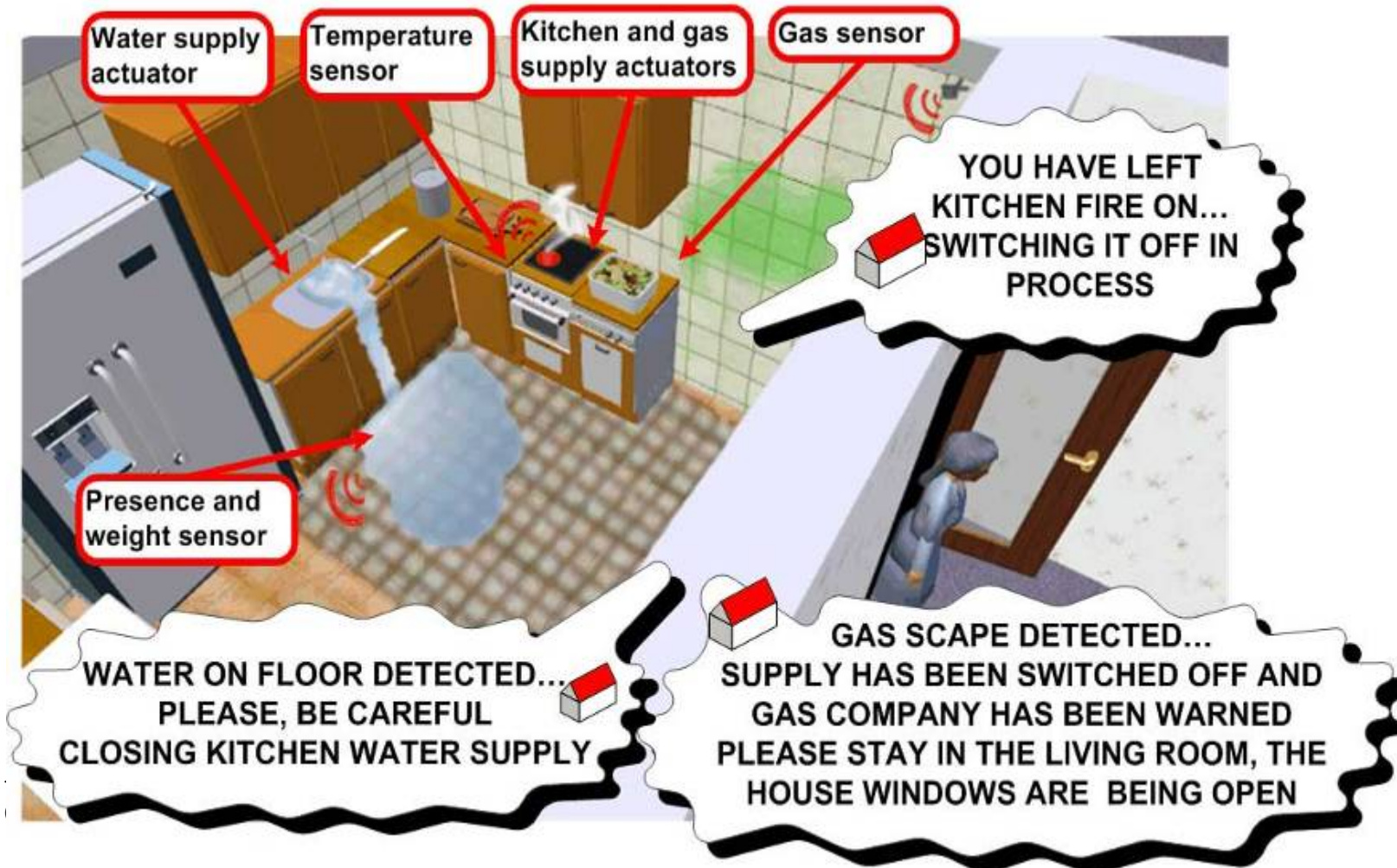 - **self-protecting**

Scenario 1: AmI at home

Subscribe to services needed!

Motivation

- ### <u>Vision (Ambient Intelligence Systems)</u>

  - Invisible, pro-active (= ambient) computer support

  - Affecting living at home

    · Emergency support (e.g., detection of burning stove)

    · Health support (e.g., detection of fallen unconscious person)

    · Assistance (e.g., support for cooking of vision-impaired people)

    · Comfort support (e.g., personalized infotainment)

  - **Affecting working**

    · **Intelligent work place (e.g., „Virtual Office of the Future")**

Scenario 2: AmI at work / office

- **distributed cooperative engineering**

  · **situation and context awareness**

- **pervasive cooperation**

  · **seamless media integration**
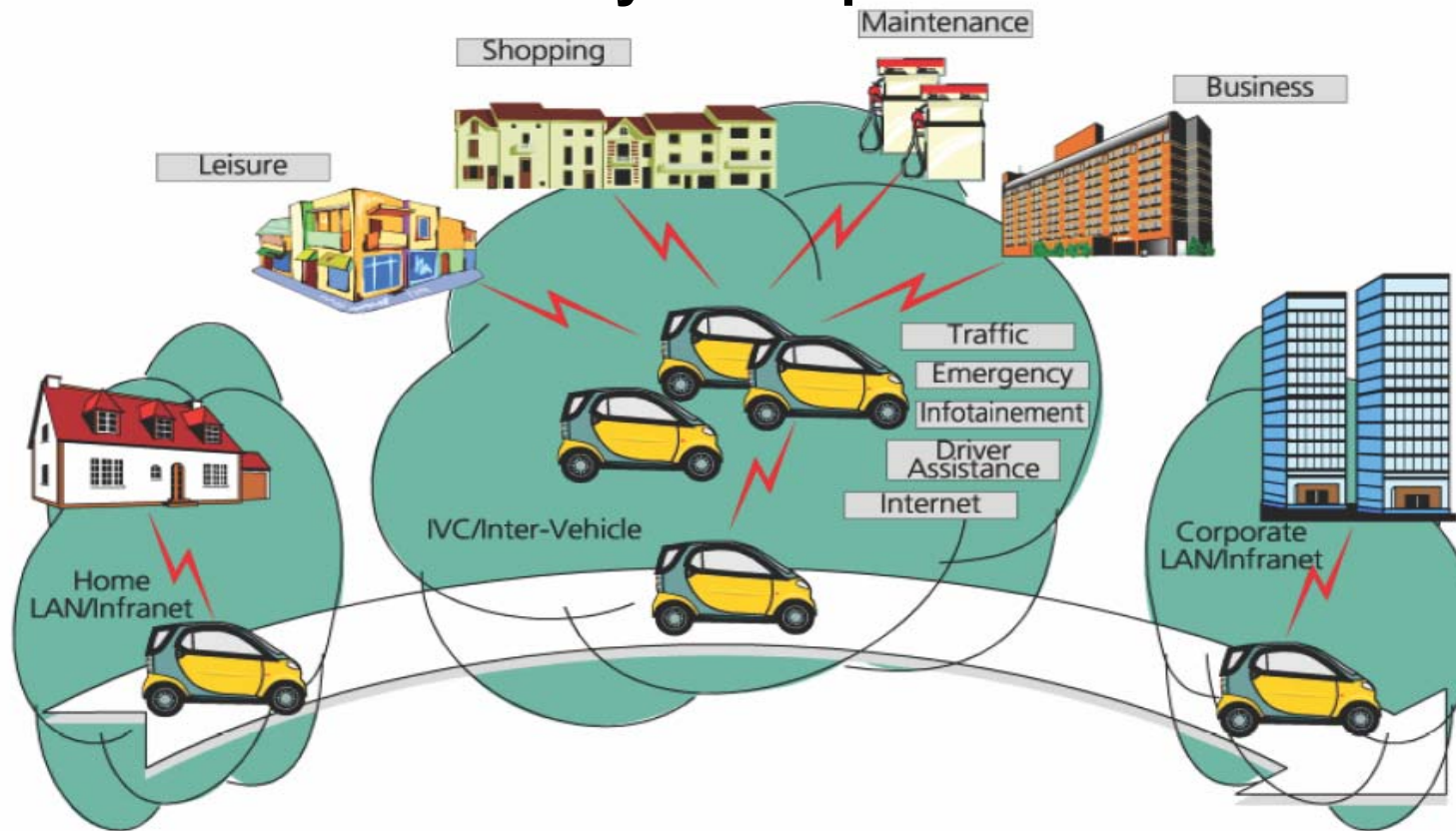
- **presence & process awareness**

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Motivation

- ## <u>Vision (Ambient Intelligence Systems)</u>

  - Invisible, pro-active (= ambient) computer support

  - Affecting living
    - Emergency support (e.g., detection of burning stove)
    - Health support (e.g., detection of fallen unconscious person)
    - Assistance (e.g., support for cooking of vision-impaired people)
    - Comfort support (e.g., personalized infotainment)

  - Affecting working
    - Intelligent work place (e.g., „Virtual Office of the Future")

  - **Affecting mobility & leisure**
    - **Games (e.g., simulated reality games)**
    - **Traffic (E-Traffic Mgt)**
    - **Navigation (e.g., tourist system, building navigation)**
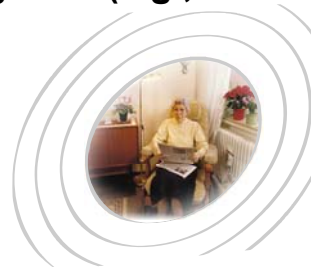
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Scenario 3: AmI at mobility / transport

Motivation

- ## <u>Challenges</u>

  - **R&D**

    - **Development of such systems requires highly interdisciplinary cooperation**: Engineers, medical science, … must collaborate

    - **Systems must be trustable (highly reliable, safe and certifiable)**: Quality of service guarantees must be achieved for highly dynamic & adaptive systems

  - **User acceptance**

    - **Usability is essential**: User interface technology must be advanced (Man-machine to multi-modal machine-man interface)

    - **Data privacy is crucial for acceptance**: Data privacy via technology & appropriate expectation

  - **Commercialization**

    - **Business cases are needed for industrial engagement:** Health insurance systems must accept AAL systems as viable alternative

    - **Standardization drives wide-spread acceptance:** Standards must be developed with all stake holders

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German Research Landscape incl. Fraunhofer Organization

Universities

Max-Planck Institutes

Fraun-hofer Institutes
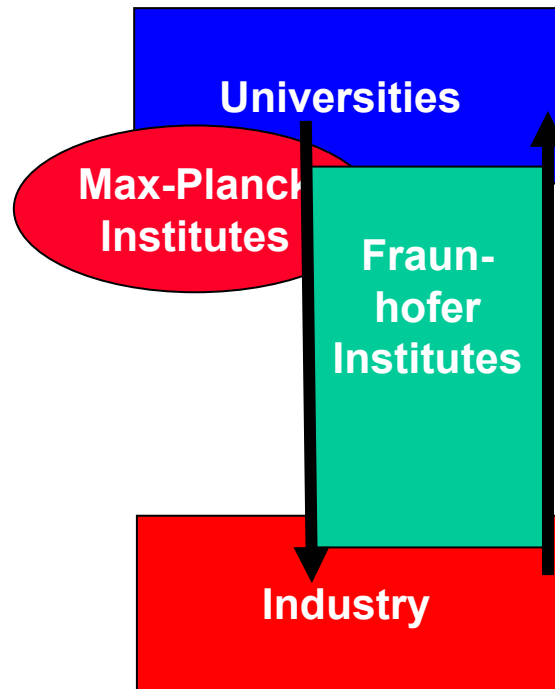
Industry

- Basic Research
  - Universities
  - 65 Max-Planck Institutes
- Applied Research & Technology Transfer
  - 58 Fraunhofer Institutes
- Industry

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Fraunhofer Organization

Named after: Joseph von Fraunhofer (1787-1826)
                          a successful researcher, inventor and
                          entrepreneur

Role of the Fraunhofer   Germany's leading organization for applied
Gesellschaft: research and technology transfer

Size: 58 institutes with approx. 12.500 employees

Funding Volume: about 1.3 billion €, consisting of:
(as of 2006)   • 1/3 base funding (government)
                          • 1/3 public sector projects
                          • 1/3 industrial projects

**Fraunhofer Gesellschaft is Europe's largest
Applied Research Organization!**

Fraun

Kommunikationstechnik

Fraunhofer-Institutes
in Germany

**58 Institutes at
approx. 40 locations**

Itzehoe

Bremen

Hannover

Braunschweig

Golm

Berlin

Oberhausen

Magdeburg

Dortmund

Duisburg

Schmallenberg

Aachen   St. Augustin

Leipzig   Dresden

Euskirchen

Jena

Ilmenau   Chemnitz

Darmstadt Würzburg

Kaiserslautern

Erlangen

St. Ingbert

Saarbrücken   Pfinztal

Karlsruhe

Stuttgart   Freising

Freiburg

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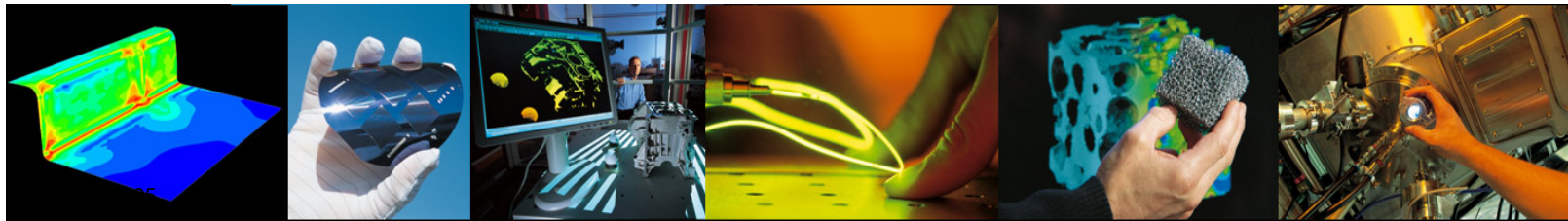Informations- und
Kommunikationstechnik

Fraunhofer ICT Group

Fraunhofer ICT Group

- 15 institutes
- 3000 scientists

58 Fraunhofer Institutes organized into 6 Groups

- **Materials & Components**
- **Production Technology**
- **Information and Communication Technology (ICT) – D. Rombach**
- **Microelectronics & systems**
- **Energy**
- **Life Sciences**

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Top 10 Research Topics of Fraunhofer ICT Group

1. **Ambient Intelligence**

2. **Software Engineering**

3. **ICT-Security and Security with ICT**

4. **Usability Engineering**

5. **Digital Entertainment**

6. **Data Analysis and Information Extraction**

7. **ICT for Production and Engineering**

8. **Simulated Reality**

9. **Next Generation Networks**

10. **Grid Computing**

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Fraunhofer Alliance „Ambient Assisted Living"

Fraunhofer Allianz
Ambient Assisted Living

- **Six (6) Fraunhofer Institutes**

- **Application of ambient technologies in all areas of daily life**

- **Objective is to**

  - **make life more effective and efficient**

  - **compensate for (age-related) deficiencies**

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International Fraunhofer Activities in AAL

- **Fraunhofer Center in Portugal (since 2007)**
  - Location: Porto
  - Cooperation with University of Porto
- **Project Group in Hungary (2005)**
  - Location: Budapest
  - Cooperation with Budapest University of Technology & Economics
- **Networks in USA (2006)**
  - State of Maryland: University of Maryland & Johns Hopkins
  - State of South Carolina: Columbia Medical Center
- **Networks in Australia (2006)**
  - University of Sydney
  - National ICT of Australia (NICTA)
- ...

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AAL Domain: Service Type and Location

	Emergency Treatment Services	**Autonomy Enhancement Services**	**Comfort Services**
Indoor Assistance	prediction detection prevention	drinking eating cleaning cooking dressing medication	logistic services services for finding things infotainment services
Outdoor Assistance	prediction detection prevention	shopping assistance travel assistance banking assistance	transportation services orientation services

- **Safety requirements decrease from left to right**

- **Relevance of a function can change over time (e.g., communication service)**

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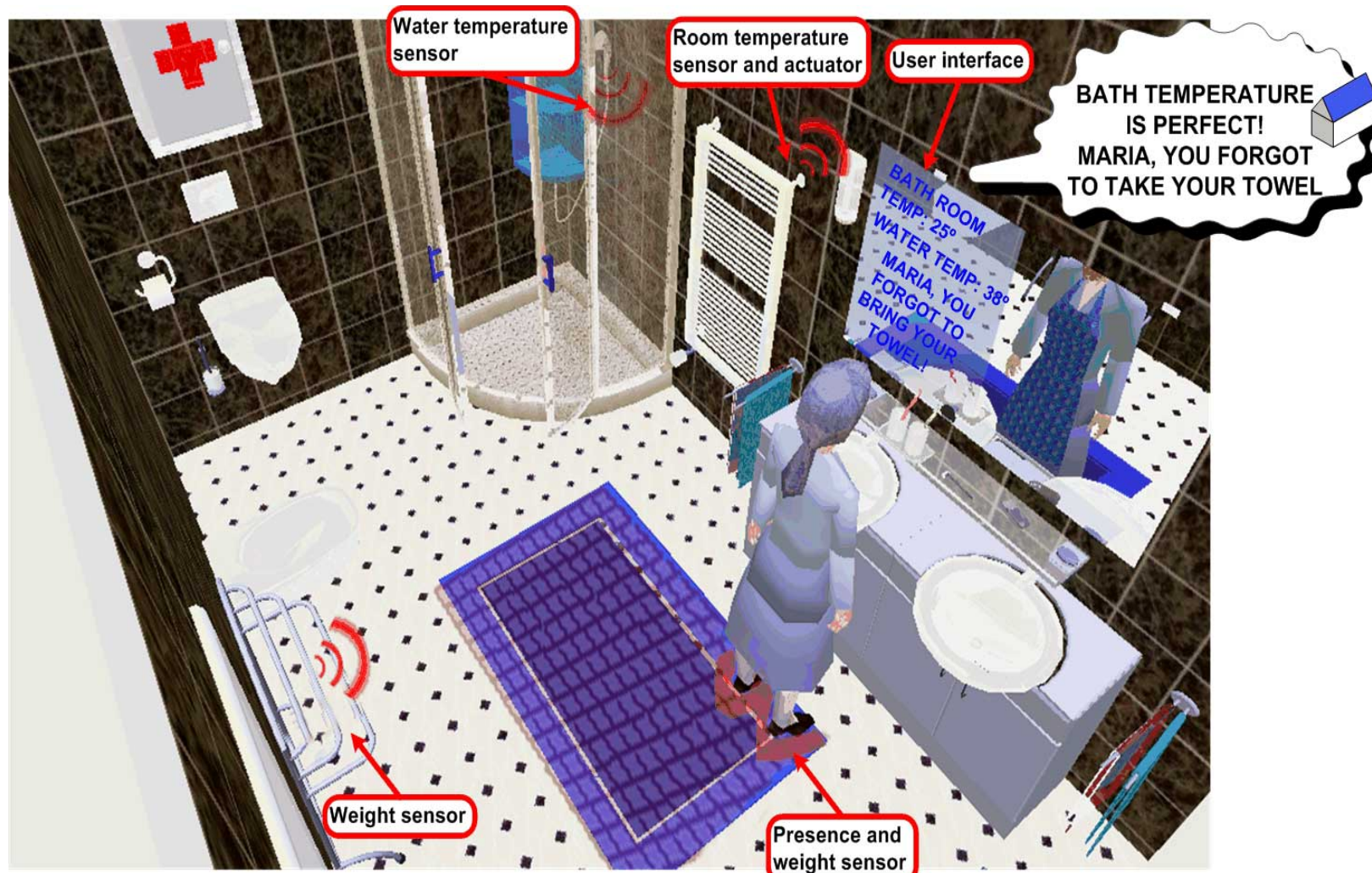**Fraunhofer** Verbund Informations- und Kommunikationstechnik

Ambient Assisted Living

- **Example components**

  - **Bath room comfort system**

  - **Collection of vital data**

  - **Medication management**

  - **Mobile tele-monitoring for heart conditions**

  - **Etc.**

Bathroom Comfort System

Collection of Vital Data

Recording of vital data with sensors embedded in matraces

• **Collection via pressure sensors (or hearing/vision aids)**

• **Storing of data in smart house system**

• **Visualization and evaluation of data via Home-PC or internet**
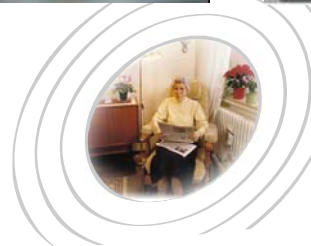
• **Avaliability to visiting care person**

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Medication Management

- **Goal**

  - **Manage medication portfolio**

    - **Expiration of dates**

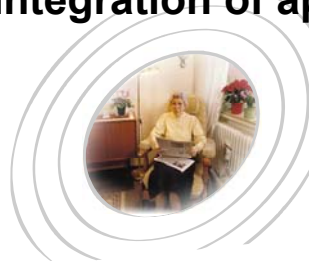   - **Lack of supplies**

- **Realization**

  - **Equipment of medication packages with smart labels**

  - **Equipment of medication cabinet with transponder reading station**

  - **Connection of reading station to service gateway**

  - **Integration of appropriate user interfaces**

er 2007

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Mobile Tele-Monitoring for Heart Conditions

- **Goal**
  - **Support people with increased risk of heart conditions (prevent emergencies)**
  - **Sustain independent life**

- **Requirements**
  - **Permanent monitoring of EKG, blood pressure, and oxygen saturation (mobile)**
  - **Robustness (24 hours x 7 days)**

- **Realization**
  - **Integration of micro sensors**
  - **Online transfer of data to medical personnel**

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Health Sector (overall)

- **Visions**
  - **Integrated health information systems**
    - · **Non-redundant personalized information**
    - · **Available anytime, anywhere**
    - · **To physicians, nurses, care takers (& devices)**
  - **Intelligent support for diagnosis & theraphy**
    - · **Knowledge-based information systems**
    - · **Remote surgical support**
  - **Safe medical devices**
    - · **Avoid accidents**
    - · **Ease certification**
  - **Ambient intelligent support of sick & elderly (better: people with special needs)**

Health Sector (overall)

- **Challenges**

  - Non-intrusive monitoring

  - Data availability vs. data privacy (e.g., individual health cards)

  - High safety standards (certification)

  - Easy usability (medical personnel complain about todays's system as requiring instead of saving time)

  - Etc.

Example Project

- **Emergency recognition and prevention (e.g., reducing the number of fallen elderly people found l**

- **System has been tested in Assisted Living Lab @ Kaiserslautern**

- **System is close to first practical test with Emergency Unit of Hospital in Kaiserslautern**

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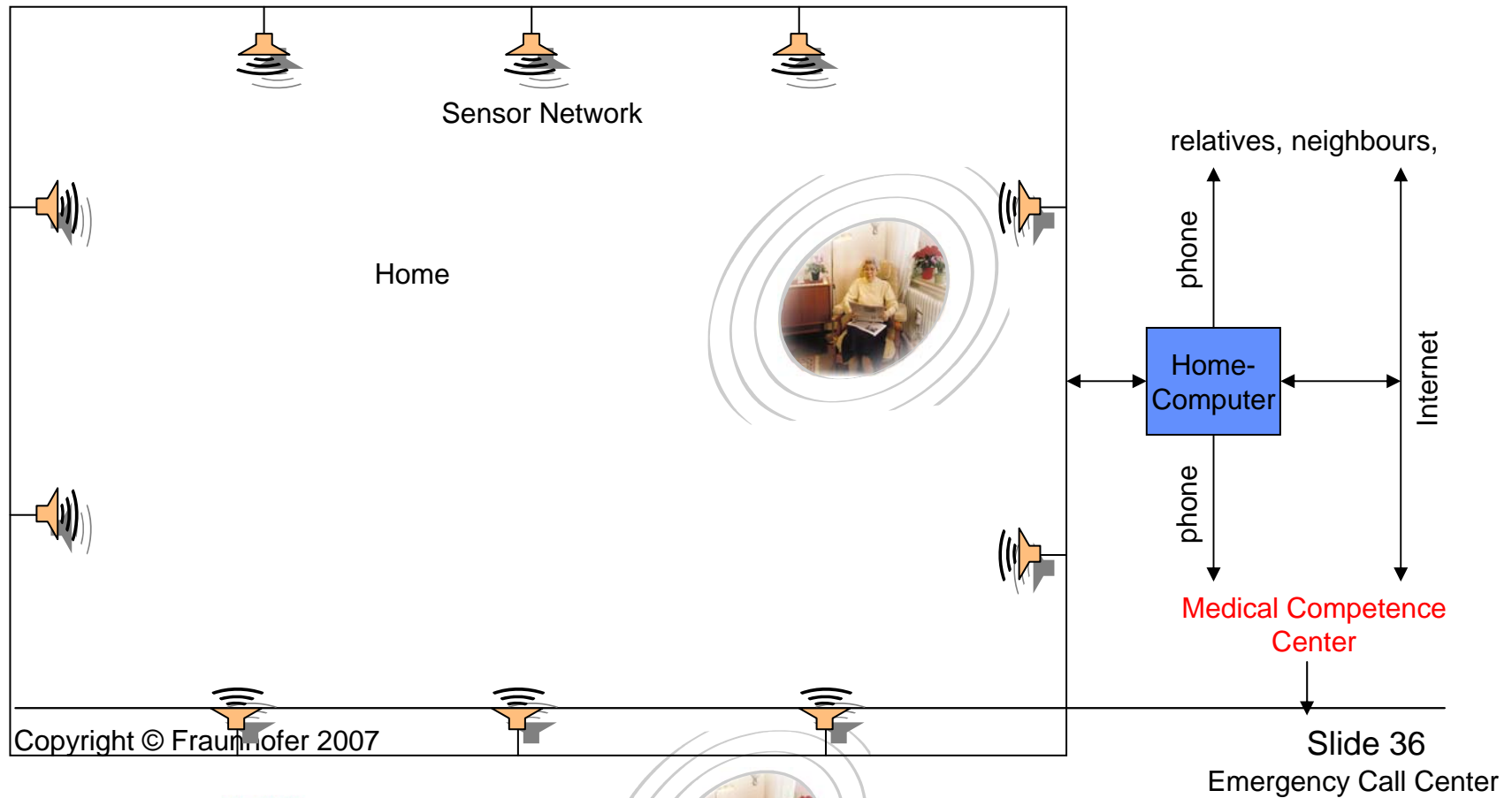- **Relevance of a function can change over time (e.g., communication service)**

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"Home Alone and in Danger"-Facts
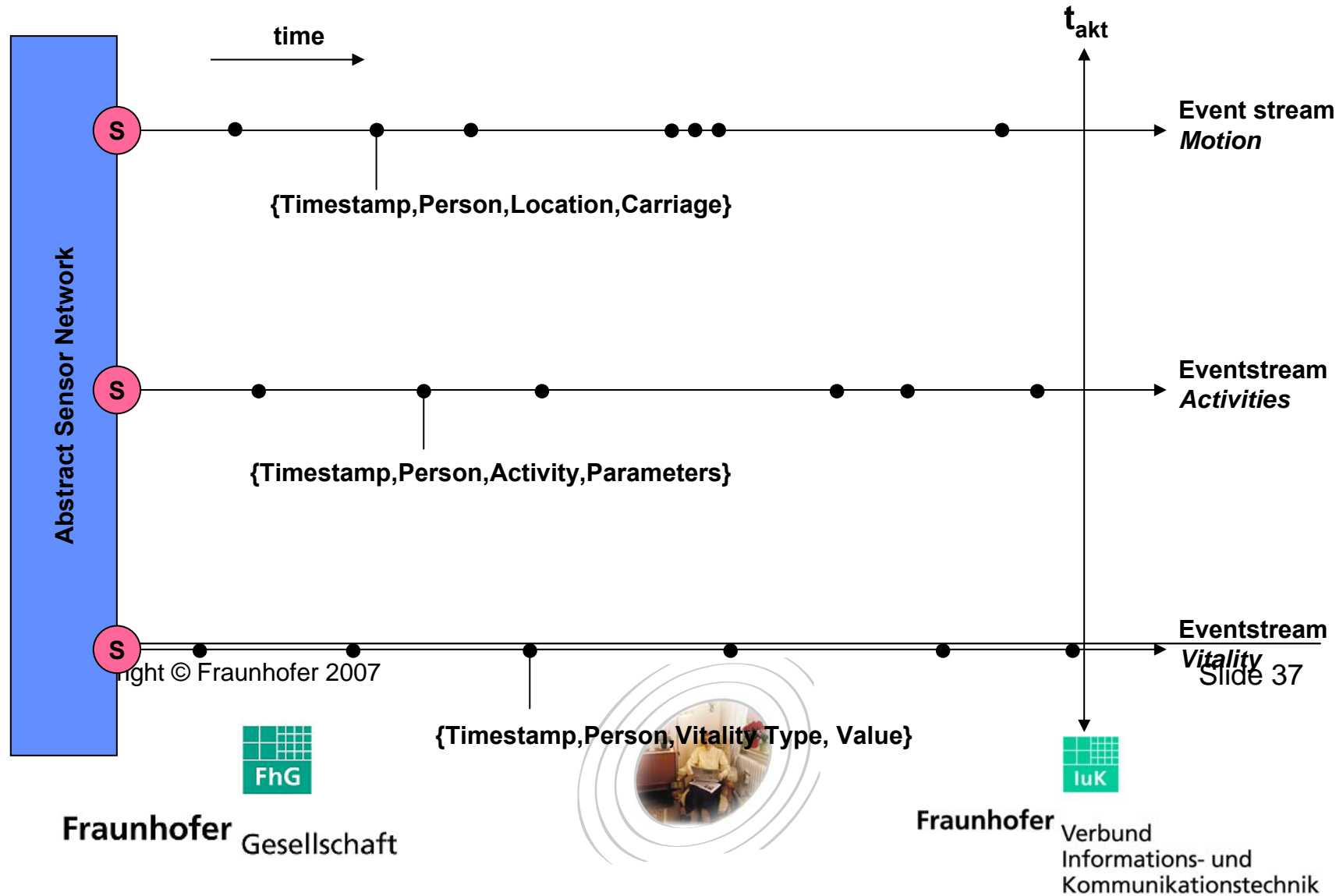## (study in state of Rhineland Palatiate)

- **Inclusion criteria:**
    - **person lived alone**
    - **found helpless**
    - **found dead at home**
- **n=387 events, 3,7 % of 10.402 total calls**
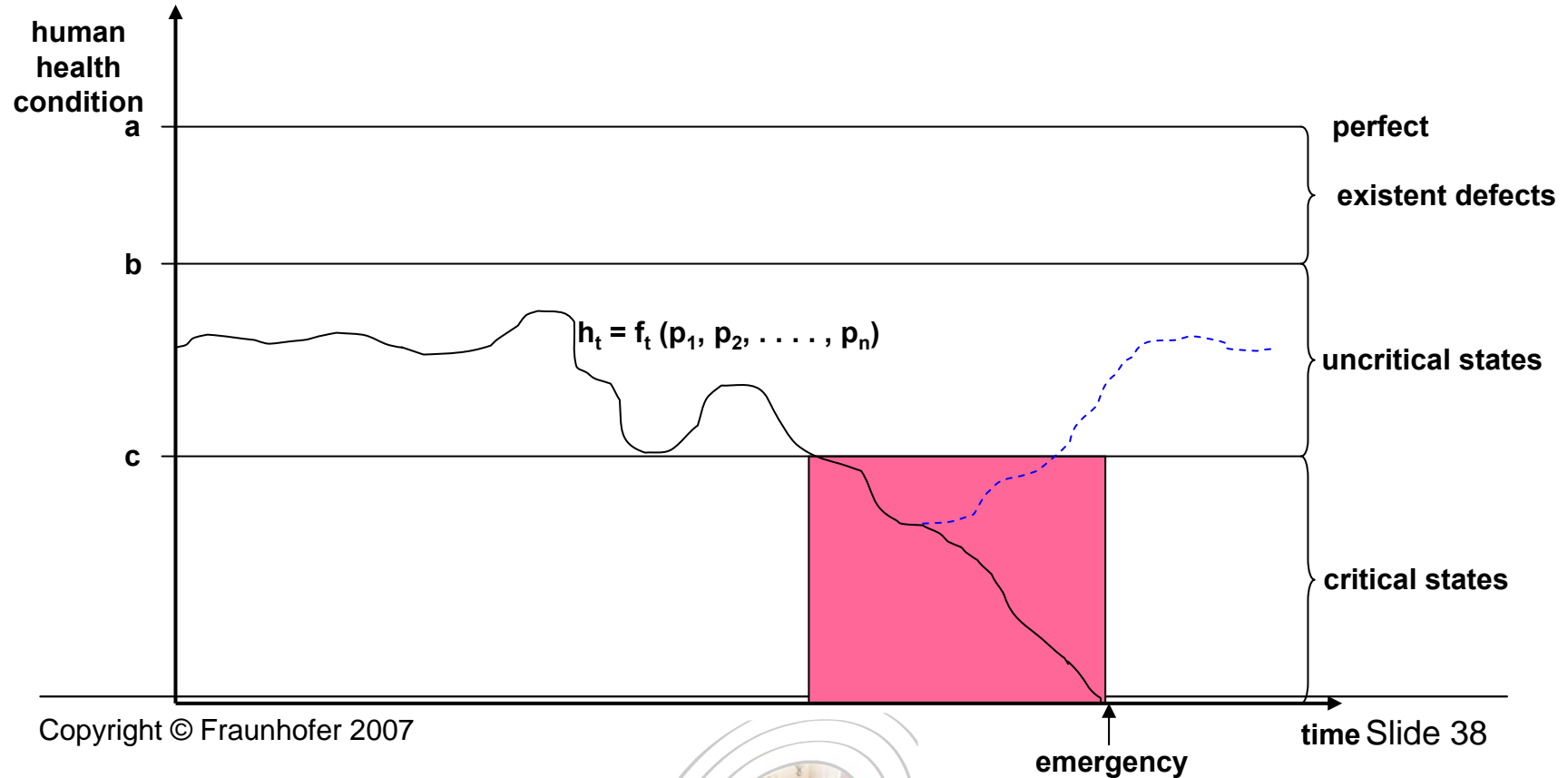- **12 weeks**
- **median-age: 73 years**

System Concept

Sensor Network

Home

relatives, neighbours,

phone

Home-Computer

Internet

phone

Medical Competence Center

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Emergency Call Center

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Realization Model

time

t_{akt}

Abstract Sensor Network

(S)

Event stream
Motion

{Timestamp,Person,Location,Carriage}

(S)

Eventstream
Activities

{Timestamp,Person,Activity,Parameters}

(S)

Eventstream
Vitality

Slide 37

{Timestamp,Person,Vitality Type, Value}

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Grand Challenge: Human Disability Model

human
health
condition

a — perfect

existent defects

b

$h_t = f_t (p_1, p_2, \ldots , p_n)$

uncritical states

c
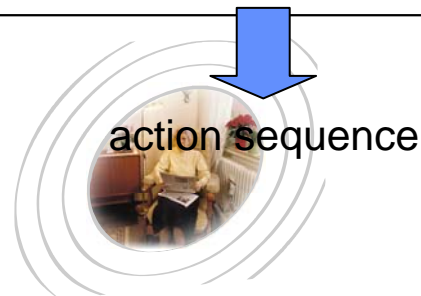
critical states
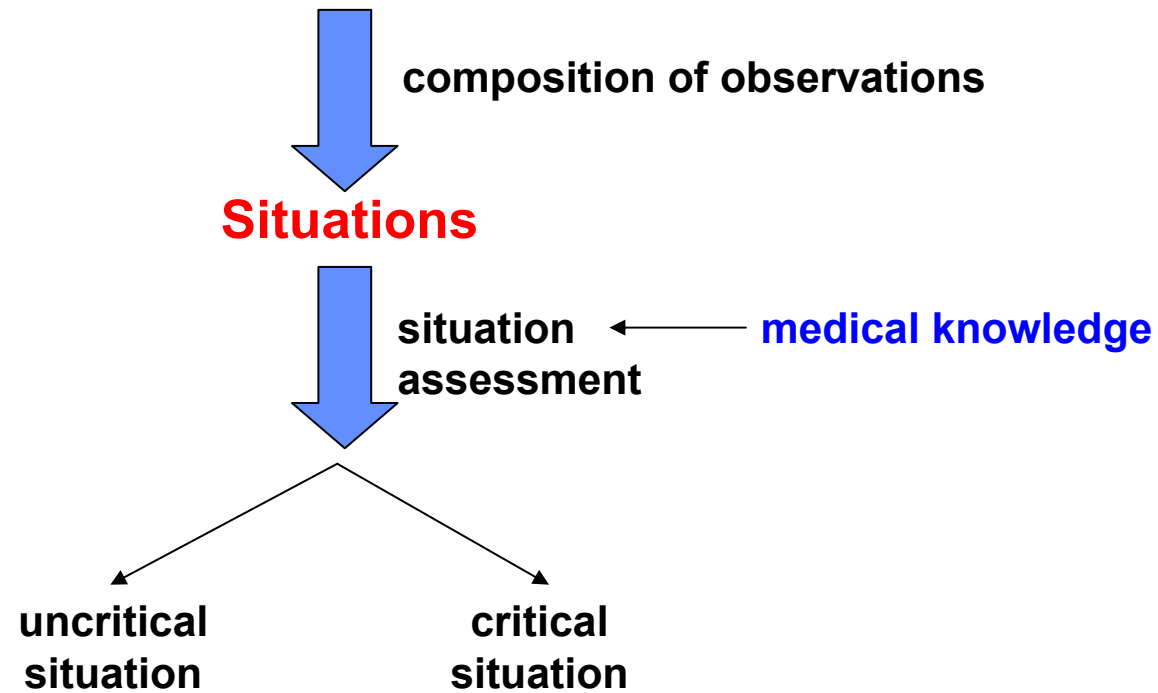
time

emergency

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Human Disability Model Approximation

{ Person behavior monitoring within time window Δt}

composition of observations

Situations

situation ← **medical knowledge**
assessment

uncritical **critical**
situation **situation**

action sequence

A Human Disability Model: Situations

- **A *situation* is a predicate, that describes a state of a person**

    S_1: **Person is lying on the floor**

    S_2: **Person has not left toilette for 45 minutes**

    S_3: **Person has a pulse < 40**

    S_4: **Person has a blood pressure > 200**

    S_5: **Person does not respond to a call**

- **Critical situation indicators**

    $I_1 = S_1 \wedge S_3 \wedge S_5$

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A Human Disability Model: Actions

- **An *action* is a system reaction on the detection of a critical or emergency situation**

  A1: Remind of drinking
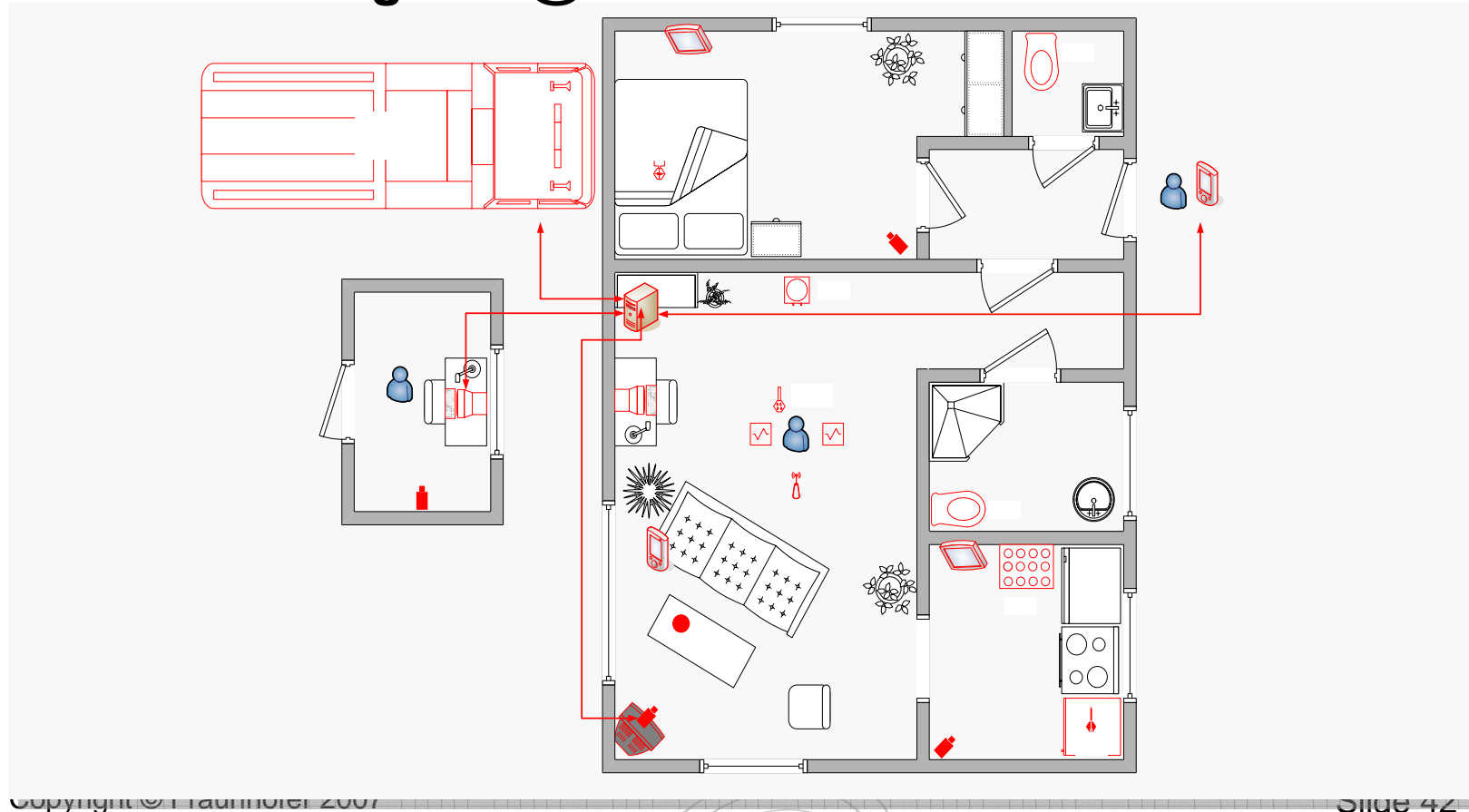
  A2: Warn against spoiled food

  A2: Call relative

  A3: Emergency Call

- **Actions are bound to critical situation indicators**

  $$S_1 \wedge S_3 \wedge S_5 \rightarrow A_3$$

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Assisted Living Lab @ Fraunhofer IESE

Emergency
service

Assisted Living Lab @ Fraunhofer IESE

German-Hungarian Project BelAmI

- Bay Zoltan Foundation, Hungary (BZAKA)

- Budapest University for Technology & Economics (BUTE)
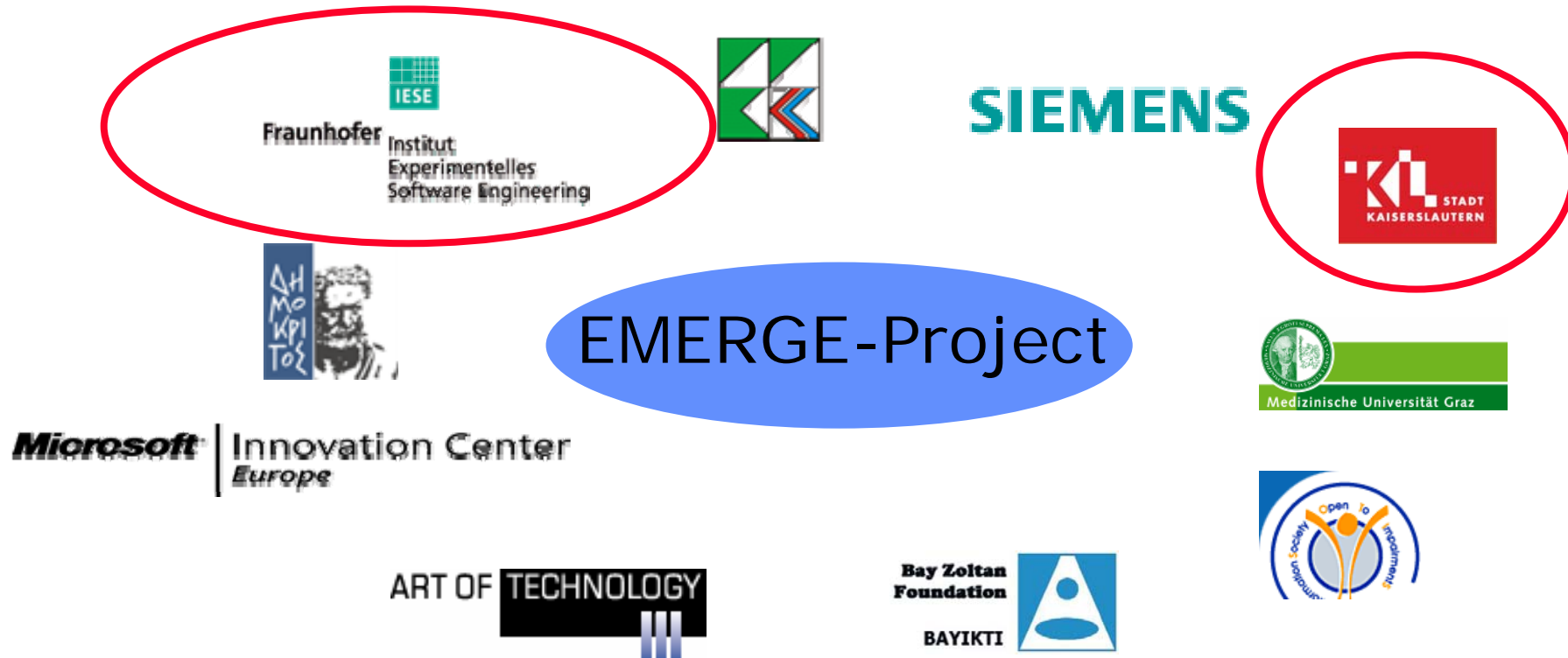
- Szeged University, Hungary
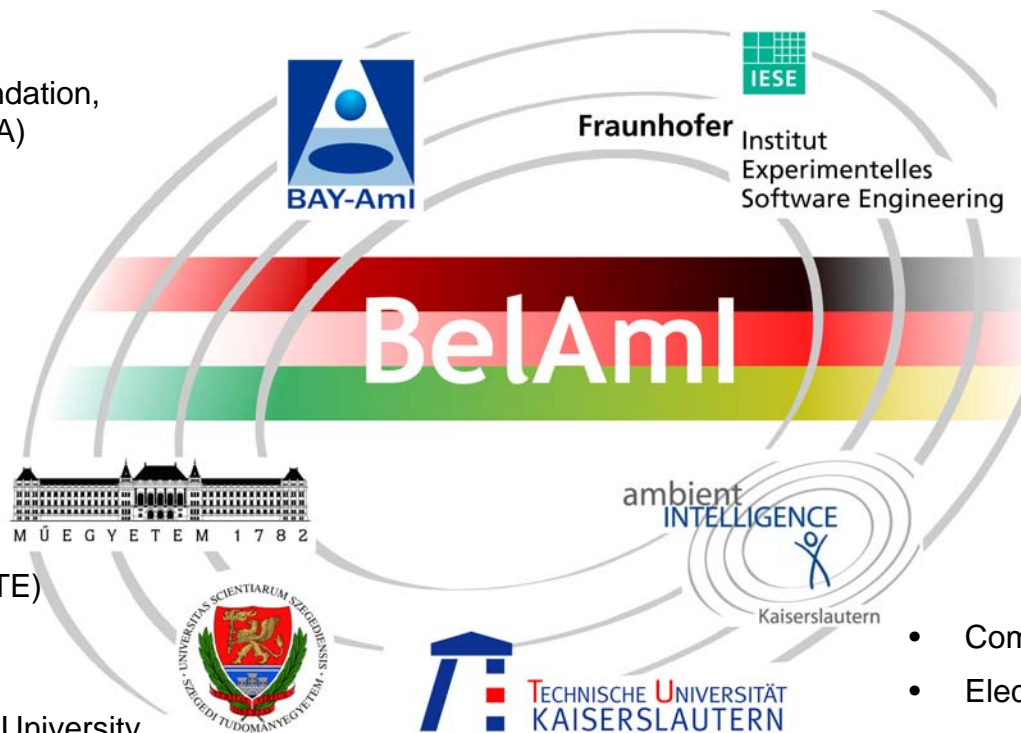
- Computer Science

- Electrical Engineering

EU-Project EMERGE: Partners

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Summary

- **Ambient Intelligence (AmI) Systems will**
  - **Represent the 4th generation of computing services (after main frame, PC, hand-helds)**
  - **Affect our daily living, working, etc.**
- **Ambient Intellience (AmI) based Assisted Living will**
  - **Enable extended independent living for elderly people**
  - **Provide „payable" care solutions despite the age pyramid**
  - **Support Incremental installation according to personal needs**
- **Commercial solutions are around the corner (components exist)**
- **Huge challenges**
  - **Inter-disciplinary, solution-oriented R&D needed**
  - **Development of usable, trustable & robust solutions**
  - **Support from health insurance industry & medical system**
  - **Business model for industry**
  - **Solutions wrt. data privacy**
  - **Education (wide-spread ICT literacy)**