Honeywell

Independent LifeStyle Assistant™ (I.L.S.A.)

A NIST ATP Program

Karen Zita Haigh
Karen.haigh@honeywell.com

i.L.S.A.

Team Members

Honeywell:

- John Allen
- Peter Bergstrom
- Peter Bullemer
- Todd Carpenter
- Zhao Chen
- Gary Determan
- Wende Dewing
- Michael Dorneich
- Kevin Driscoll
- Anthony Faltesek
- Denis Foo Kune
- **Christopher Geib**
- Michael Good
- **Valerie Guralnik**
- **Karen Haigh**
- **Steven Harp**
- **Steve Hickman**
- Geoffrey Ho
- **Raj Gopal Prasad Kantamneni**
- Joe Keller
- **Liana Kiff**
- **Stephen Metz**
- Charles Obranovich
- Olu Olofinboba
- **John Phelps**
- **Tom Plocher**
- Michelle Raymond
- Dal Vernon Reising
- **Rose Mae Richardson**
- Victor Riley
- Jeff Rye
- Jon Schewe
- **Tricia Syke**
- **David Toms**
- **Ryan Vanriper**
- Don Vu
- **Tom Wagner**
- **Rand Whillock**
- Stephen Whitlow
- **Woodrow Winchester**
- Peggy Wu

Behavioral Informatics, Inc.

- Anthony Glascok
- David Kutzik

EverCare, Inc.

- Nancy Williams

SIFT, LLC

- Harry Funk
- Chris Miller

University of Minnesota:

- Kathleen Krichbaum

Weiser Scott & Assoc., Inc.

- Janet Myers

In a Nutshell

Program Objective

Develop an intelligent home automation system with situation awareness and decision-making capability based on integration of diverse sensors, devices, and appliances to support caregivers and enable elderly users to live independently at home.

Programmatics:

- A NIST Advanced Technology Program
  - 2.5 years (Nov '00 – Mar '03)
  - $5.3 Million
- Lead by Honeywell
  - Behavioral Informatics, Inc.
  - SIFT, LLC
  - United Health Group EverCare
  - University of Minnesota School of Nursing

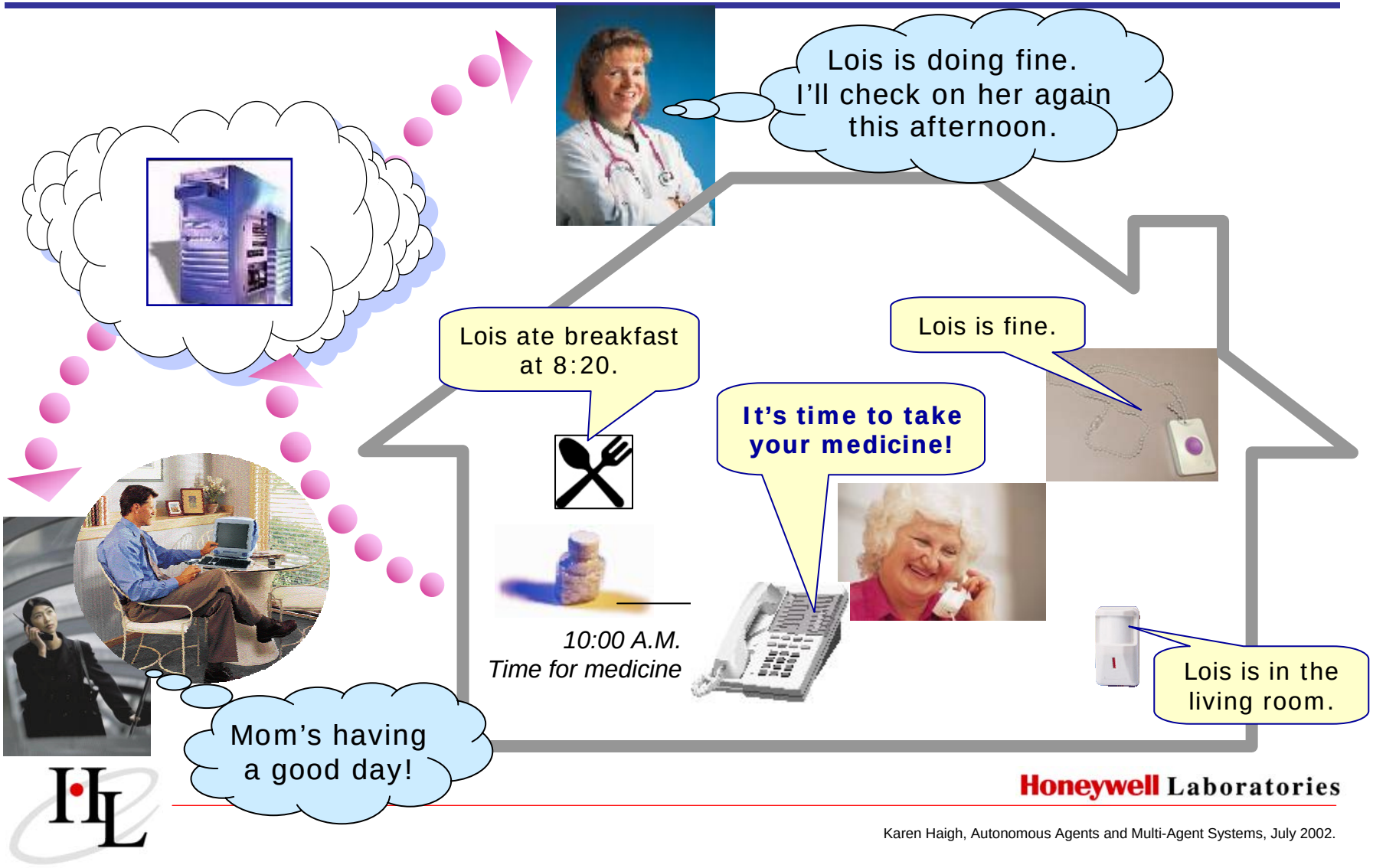
Benefits:

- Support elder independent living
- Provide peace of mind to caregivers
- Support efficient quality care for caregiving organizations
- Cost savings for government and industry
- Market growth for in-home product producers

The Vision

- Gather information about elder, activity, and home status by listening to the home and communicating with devices
- Assess the need for assistance based on the system's understanding the elder's condition and what activities are going on inside the home
- Respond to a given situation by providing assistance to the elder and getting help when necessary
- Share health and status information with authorized caregivers to help improve the quality and timely delivery of care

The Vision



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Finding Relevant Features

Factors contributing to institutionalization

- caregiver burnout
- medication mgmt, medical monitoring
- mobility, wandering, toileting, dementia, safety
- usability

Technological feasibility & match

- demonstrable in 30 months
- fits I.L.S.A. vision of passive monitoring & support

Initial Feature Set

Monitoring Functions

- Mobility (general activity level)
- Verify medication taken
- Panic button activation
- Toileting
- Eating
- Environment (comfort/intrusion)

Response Functions

- Alarms
- Alerts
- Notifications
- Activity Reports

Service Features

- Reminders
- Internet & phone access to elder activity
- Caregiver to-do lists
- Coordinate multiple caregivers

Usability Features

- Password-free elder interactions
- Operational modes
- Queries to elders
- Feature Controls

User Interfaces

- Elder: Phone, webpad, eFrame
- Caregiver: Web, phone, email

Software Architecture Requirements

Each ILSA client and home will be very different and have specialized needs, so the system must be:

- rapidly deployable,
- easily configurable,
- highly modular, and
- adaptive to the environment.

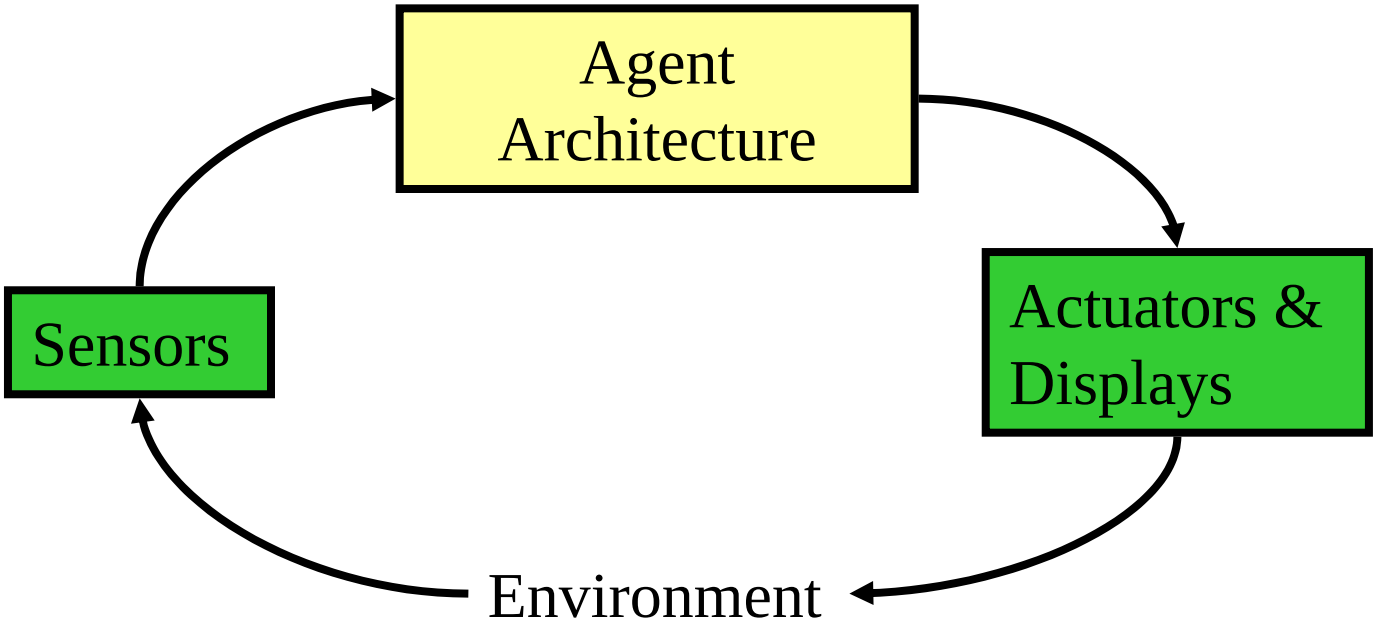
Modularity is critical both to functionality as well as expandability for a number of reasons:

- Integrate 3rd party functional units
- Flexibility of sensor and actuator suites
- Expansion of ILSA capabilities over time

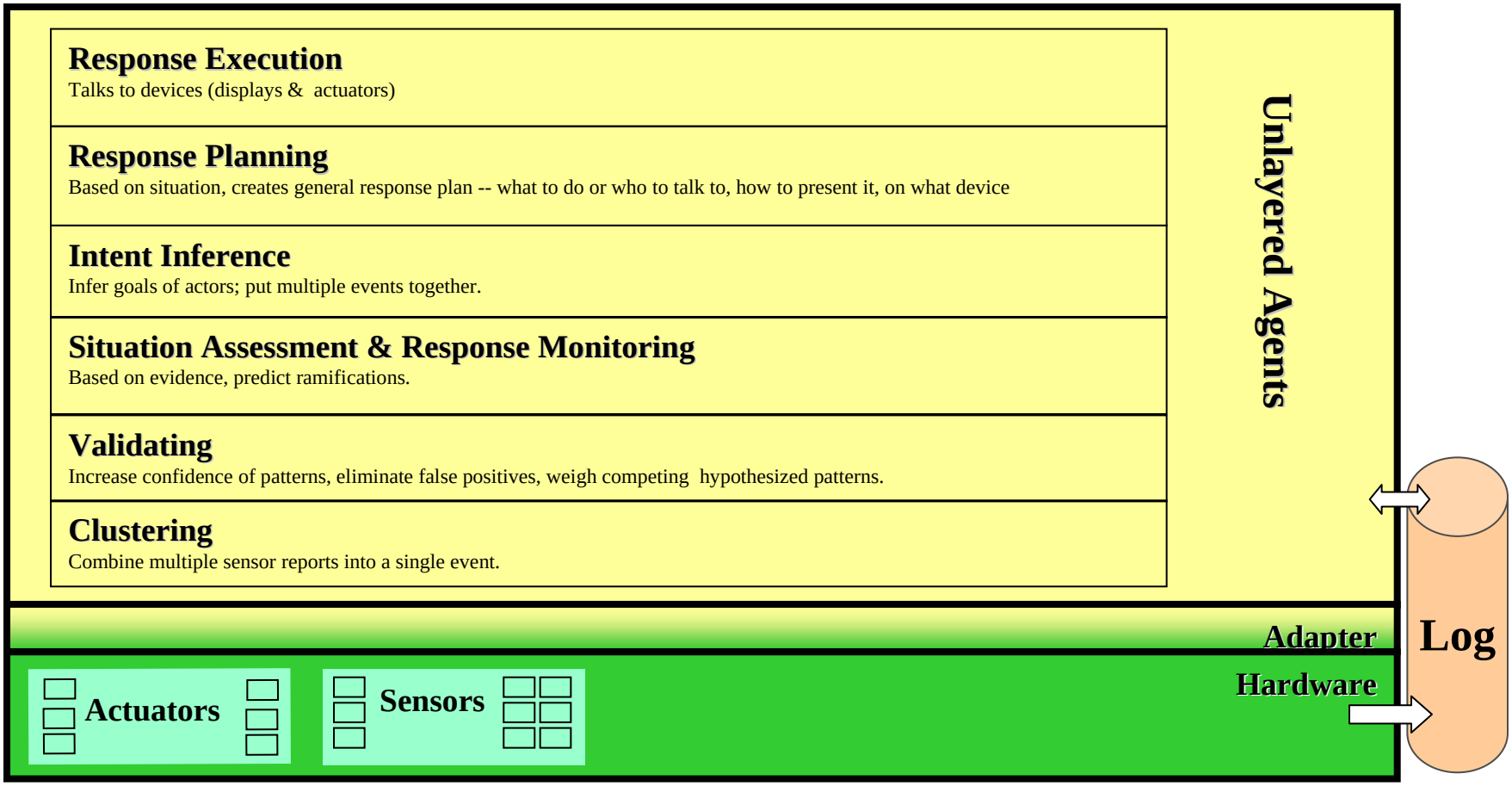
Agent Architecture

Highly distributed -- can compute anywhere

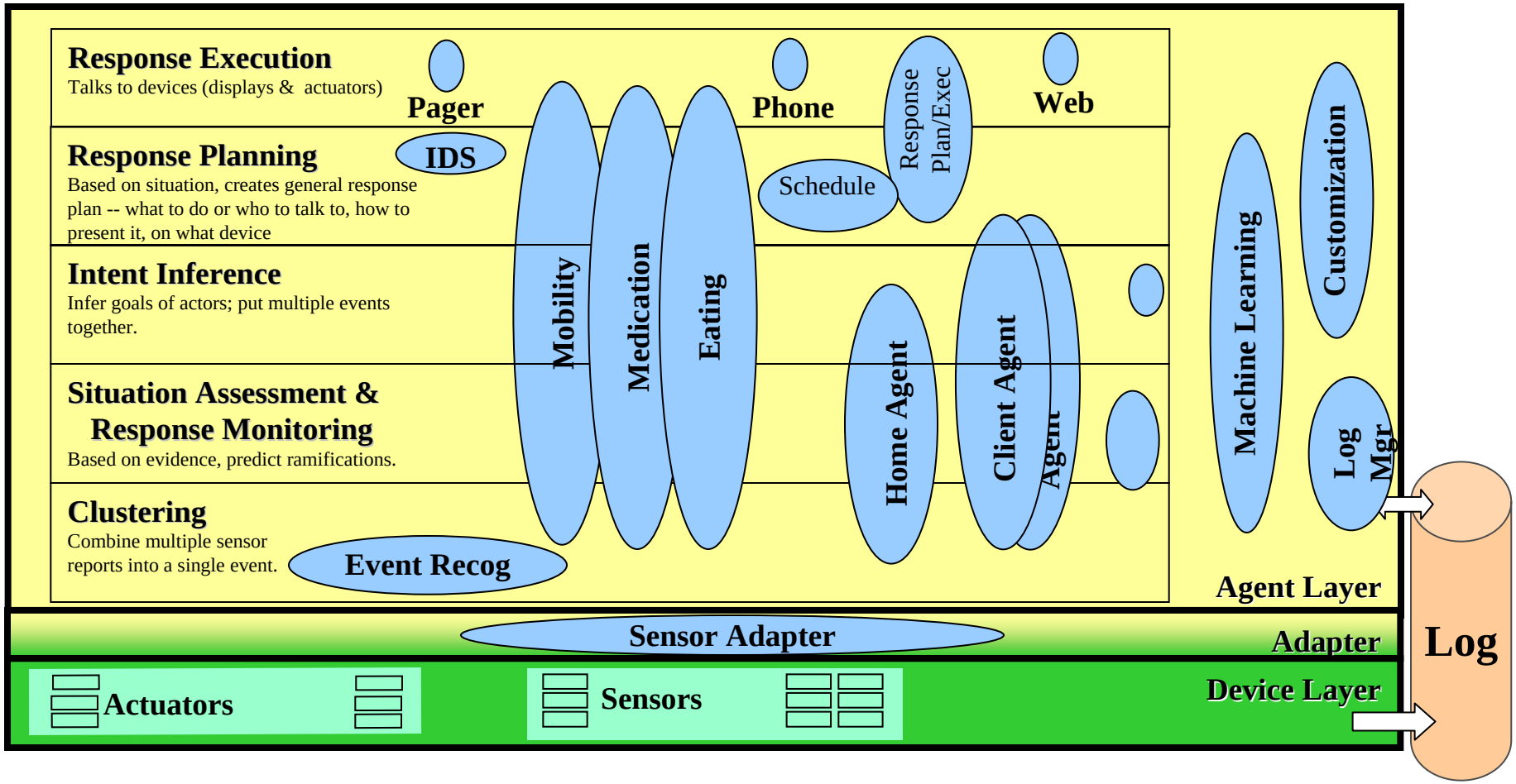
Highly modular -- can change or incorporate agents



Layered Agents



Agent Architecture



ILSA Agents

Agents group functionality, e.g.

- Mobility monitor
- Medication monitor
- Client interaction module
- Device controllers

Agents group technical capability, e.g.

- Machine Learning
- Task tracking
- Response Planning

Device Agents

Intelligent, coordinated integration of multiple sensors, effectors and and displays

- Use standard communication protocols and the Ontology to seamlessly incorporate new devices
  - » sensing into the situation-aware infrastructure
  - » actuation / displays from response planner
- Cluster information from low cost, fault-vulnerable devices of disparate types to provide information about the client's behaviour

Task Tracking

Recognize what the client is doing:

- Considers all hypotheses and actively reweights them as new evidence is added
- Can recognize that one sensor sequence may mean two different things (competing possibilities),
- Be aware of how confident it is in the recognized sequence (e.g. competing possibilities, or noisy sensors),
- Handle missed actions (e.g. when a sensor failed)
- Recognize what the person was TRYING to do, even if they didn't actually succeed or have not yet completed the task

Response Planning

Given a (set of) recognized situations, decide what to do:

- *who*: client, caregiver, house, external environment
- *what*: gather more evidence, interact (alarm, alert, remind, notify)
- *where*: location of devices
- *when*: degree of intrusiveness (severity)
- *how*: multiple devices, presentation format

...in a coordinated way, without overloading the resources (device or human)

Adaptive User Interfaces

Adaptive Interaction Design

- Use models of domain, task, and user(s) to dynamically design and create interactions
- Incorporate more divergent multi-modal devices
- Support less capable audiences, with changing capabilities
- Support a more varied, less predictable home situation

Machine Learning

Learn models of the actors and environment to automatically improve the performance of the system:

- what is normal / unusual, for elder, caregiver and other environmental factors
- what is the most effective technique to use
- understand sensor reliability
- etc

Domain agent example: Medication

- Situation assessment from sensor events
- Asks Task Tracker for client intent
- Requests alerts and notifications for anomalous events
- Reminds according to schedule and recent activity
- Uses machine learning to adjust schedule, and likely task performance

Agent Architecture Selection

Simplified Tools Comparison				
	UPnP	FIPA-OS	JADE	OAA2
Easy to use	NO	NO	YES	YES
Stable	N/A	NO	YES	N/A
Uses a widely accepted standard	YES	YES	YES	NO
Multithreaded execution env	NO	YES	YES	YES
Lib. of interaction protocols	NO	YES	YES	YES
Administration support	NO	YES	YES	YES

Domain Ontology

A common vocabulary that lets agents communicate with precision about the world

It provides standard interpretations for words

- that might otherwise be dangerously ambiguous

It structures the domain knowledge in ways that allow it to be analyzed,

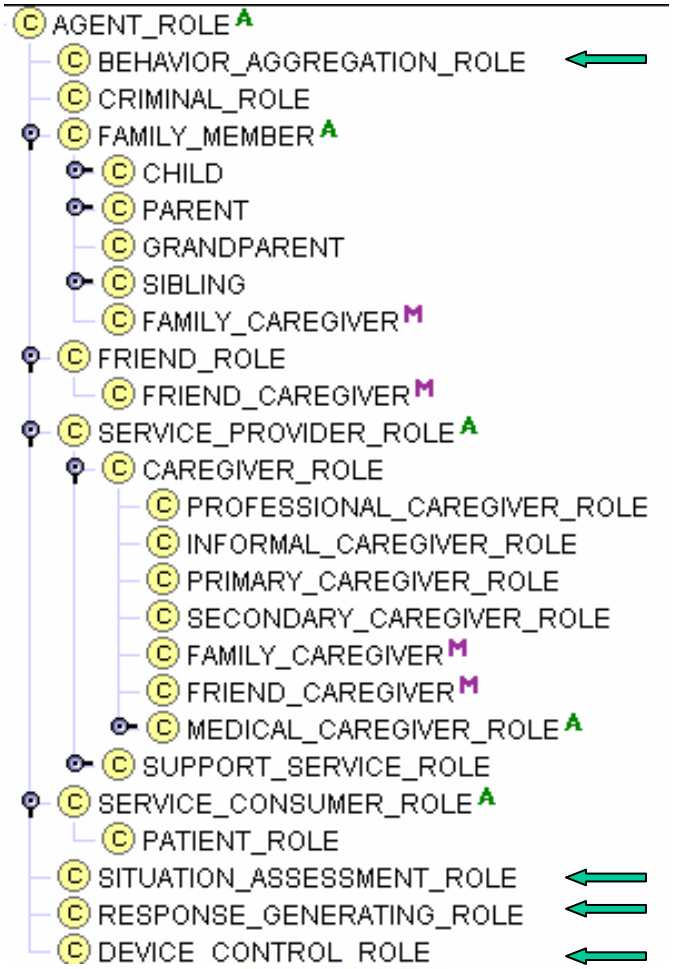
- making assumptions more explicit

Currently undergoing review with 3rd parties

Domain Ontology (II)

1000 classes, in hierarchy, top levels include:

AGENT
AGENT_ROLE
COMMUNICATION_ACT
PHYSICAL_OBJECT
MEASURABLE_ATTRIBUTE_TYPE
PLACE
PREDICATE
PROCESS
RELATION_TYPE
TEMPORAL_OBJECT



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Field Tests

Installations for 20 elders, mix of

- independent homes
- independent elders in communal living facilities

Hardware installed July 13-31

I.L.S.A. tests running August - December

Publications

Christopher W. Geib and Robert P. Goldman, 2001. "**Probabilistic Plan Recognition for Hostile Agents**," Proceedings of the FLAIRS 2001 Conference, October 2001. Pages 580-584.

Several papers to appear at AAAI-02 Workshop on "Automation as Caregiver," July 2002.

K. Z. Haigh, J. Phelps and C. W. Geib, 2002. "**An Open Agent Architecture for Assisting Elder Independence**," AAMAS July 2002.

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- C. W. Geib. "**Problems with Intent Recognition for Elder Care**”
- V. Guralnik and K. Z. Haigh. "**Learning Models of Human Behaviour with Sequential Patterns**"
- K. Z. Haigh, C. W. Geib, C. A. Miller, J. Phelps and T. Wagner. "**Agents for Recognizing and Responding to the Behaviour of an Elder**"
- K. Z. Haigh and H. Yanco, 2002. "**Automation as Caregiver: A Survey of Issues and Technologies**"
- C. A. Miller, K. Z. Haigh, W. L. Dewing, 2002. "**First, Cause No Harm: Issues in Building Safe, Reliable and Trustworthy Elder Care Systems**"
- T. A. Wagner, 2002. "**Achieving Global Coherence in Multi-Agent Caregiver Systems: Centralized versus Distributed Response Coordination in I.L.S.A**.”

K. Z. Haigh, J. Phelps and C. W. Geib, 2002. "**An Open Agent Architecture for Assisting Elder Independence**", to appear in The First International Joint Conference on Autonomous Agents and MultiAgent Systems (AAMAS). July 2002.