Towards the Evolution of Smart Information Systems

Ajith Abraham

Machine Intelligence Research Labs (MIR Labs)

http://www.mirlabs.org

ajith.abraham@ieee.org

http://www.softcomputing.net

Presentation Outline

- Smart Systems of the Future - Digital ecosystems
- Building Smart Systems
- Application Examples
- Conclusions

Digital Ecosystems and E-Society

- With the Internet as driving factor, socio-technical and industrial e-Networked ecosystems are about to change our lives again!
- Rocketing speed of technological ICT advances.
- As technology is getting ahead of society - the new ways disrupt the way we used to do things and even the way we used to think about the world.
- Digital Convergence
- Change the way we work, and we learn, and we live

First nation makes broadband access a legal right

July 1, 2010 -- Updated 1050 GMT (1850 HKT) | Filed under: Web

An EU report last year stated that 24 percent of the EU population had a broadband access line subscription.

STORY HIGHLIGHTS

- Minister: Reasonably priced broadband connection will be everyone's basic right in Finland
- Finland is one of the world's most wired nations, corporations include telecommunications giant Nokia
- European Union: 80 per cent of broadband lines in EU have download speeds of two mbs-plus

RELATED TOPICS

Broadband Internet

(CNN) -- Finland has become the first country in the world to make broadband internet access a legal right for all citizens.

The legislation, which came into effect Thursday, forces telecom operators to provide a reasonably priced broadband connection with a downstream rate of at least one megabit per second (mbs) to every permanent residence and office, the Finnish government said in a statement.

"From now on a reasonably priced broadband connection will be everyone's basic right in Finland," said Finnish communications minister Suvi Linden. "This is absolutely one of the government's most significant achievements in regional policy and I am proud of it.

Finland

July 01, 2010

EDITION: U.S. | INTERNATIONAL | MÉXICO
Set edition preference

CNN Tech

Home | Video | NewsPulse BETA | U.S. | World | Politics | Justice | Entertainment | Tech | Health

AT&T offers free Wi-Fi in New York City

By **Marguerite Reardon**, CNET
May 25, 2010 6:01 p.m. EDT

from cnet

AT&T's pilot program offers free Wi-Fi access to wireless and broadband customers in New York City.

STORY HIGHLIGHTS

- On Tuesday, AT&T launched a free outdoor wireless hot spot in Times Square
- The program is designed to see how Wi-Fi can help relieve wireless data congestion
- If all goes well, AT&T said it may expand the offering to other cities

(CNET) -- AT&T is offering free public Wi-Fi hot spots to help it deal with increasing congestion on its wireless network.

On Tuesday, the company launched a free outdoor wireless hot spot in New York's Times Square.

The pilot program will offer free Wi-Fi access to AT&T wireless and broadband customers using smartphones, laptops, and other Wi-Fi enabled devices. AT&T's Wi-Fi network is set up on the north side of Times Square on Seventh Avenue between 45th and 47th Streets.

New York

May 25, 2010

Internet Connectivity

	Country	Q3 09 Mbps	Q2–Q3 Change	YoY Change
-	Global	1.7	18%	13%
1	South Korea	14.6	29%	16%
2	Japan	7.9	8.2%	11%
3	Hong Kong	7.6	10%	13%
4	Romania	6.2	-0.1%	12%
5	Sweden	5.7	-5.0%	6.2%
6	Ireland	5.3	26%	73%
7	Netherlands	5.2	2.2%	18%
8	Switzerland	5.0	–	1.0%
9	Denmark	4.8	1.6%	7.7%
10	Czech Republic	4.8	-3.1%	23%
...				
18	United States	3.9	1.8%	-2.4%

Obama to announce funding to expand broadband in poor, rural areas

By **the CNN Wire Staff**
July 2, 2010 6:24 a.m. EDT

The $795 million in grants and loans President Obama will announce will be used to expand broadband connections.

Washington (CNN) -- President Obama on Friday will announce new government investments in 66 projects to expand broadband connections in rural and poor areas across the country.

The $795 million in grants and loans funded by the 2009 economic stimulus act will create 5,000 jobs and generate $200 million in associated private investment, according to information provided by the White House.

STORY HIGHLIGHTS

- Obama to announce investments in 66 projects
- $795 million in grants and loans funded by 2009 economic stimulus act
- Money will bring broadband services to rural, poor communities

"In total, tens of millions of Americans and over 685,000 businesses, 900 health care facilities and 2,400 schools in all fifty states stand to benefit from the awards," the White House said.

The money will bring broadband services to communities that "currently have little or no access, to help them better compete and do business in the global marketplace," the document said.

Health Care

- In current medicine (the discipline) professional care is encouraged. Through access to information, this model may be changed.
- Body Sensor Networks !
- ICT will play an increasingly important for curative and preventative medicine.

E-Learning

- Teachers - leave the students alone!
- E-Learning is fueling one of the most radical revolutions in education, by focused student-driven environment leveraging web-based individualized content.
- Is learning to be regarded as a universal right and accessible irrespective of geography with open educational resources accessible to everyone from everywhere?

E-Commerce

- The roaring successes of e-Bay, Amazon, and Google and others who broke the traditional models for commerce.
- Web 2.0, P2P, Social Networks, Blogs have fuelled the developments.
- The future only gets interesting as we dare to solve problems that were unsolvable at the scale we are seeing before in terms of infrastructure, platforms, data, and applications, with participatory resources like people and computing.
- Nature of e-Commerce of the future?

Computing

- Paradigm shift from silo-oriented to service-oriented architectures
- From directly accessing local computers to accessing remote computing and application services.
- Grid and Cloud infrastructures available could enhance the Internet by seamlessly integrating computers, storage, sensor networks, digital experiments and instruments.
- Users could access these resources and services through a simple Web browser, remotely, securely, transparently!
- Just as another utility, from the wall socket.

Automation

- Devices and machines will be able to discover each others with no previous knowledge on each other's type and collaborate towards the resolution of a common goal.
- They will use dynamic architectures allowing autonomous re/configuration of hardware and software structures, deploying software agents that can intelligently use web services in order to build adaptive systems.
- Semantic web services, embedded systems, wireless networks, sensor networks etc.

Global Collaboration

- Social networks have taken the lead to push the world from a traditional closed competitive environment to an open, loosely coupled, collaborative environment.

- Value by making connections through the pervasive use of the modern infrastructure and collaborative IT frameworks.

Ubiquitous City

- Ubiquitous Technology allowing internet connection anytime, anywhere -- A new world where anyone can freely connect to computer networks regardless of time and place.
- Only dreamed of in movies!
- Multifunctional Administrative City, Innovation City, Enterprise City

Managing Complexity

- ICT systems in all domains of society has opened the door to entirely new forms of social organization characterized by a high degree of decentralization.
- Myriads of artifacts and humans, connected via networks and computing elements, exhibit self-organization and unpredictability that fundamentally challenge traditional systems engineering--based upon requirements and top-down management.
- This spontaneous trend has preceded our ability as designers to comprehend and control it, while also opening new opportunities for exploiting the formidable potential of ICT advances.

Safety and Security

- From the rise of global identity theft; to nation sponsored cyber attacks and the realities of combined warfare, the safety and security of a nation, its people and its place in the global market is becoming more difficult.
- Can governments successfully fulfill their obligation to protect?
- Requires complex and integrated solutions and novel approaches.

Culture, Media and Ethics

Movies, television, cell phones, computer games, and the internet have all, in one way or another, collapsed the local into more international, creating a blur of perceptions, dreams and social mores.

The emerging, planet-wide, multi-ethnic and multi-class e-Networked discourse has upended all the verities.

Building Smart Systems

Parking a Car

Generally, a car can be parked rather easily. If it were specified to within, say, a fraction of a millimeter, it would take hours of maneuvering and precise measurements of distance and angular position to solve the problem.

⇒ **High precision carries a high cost.**

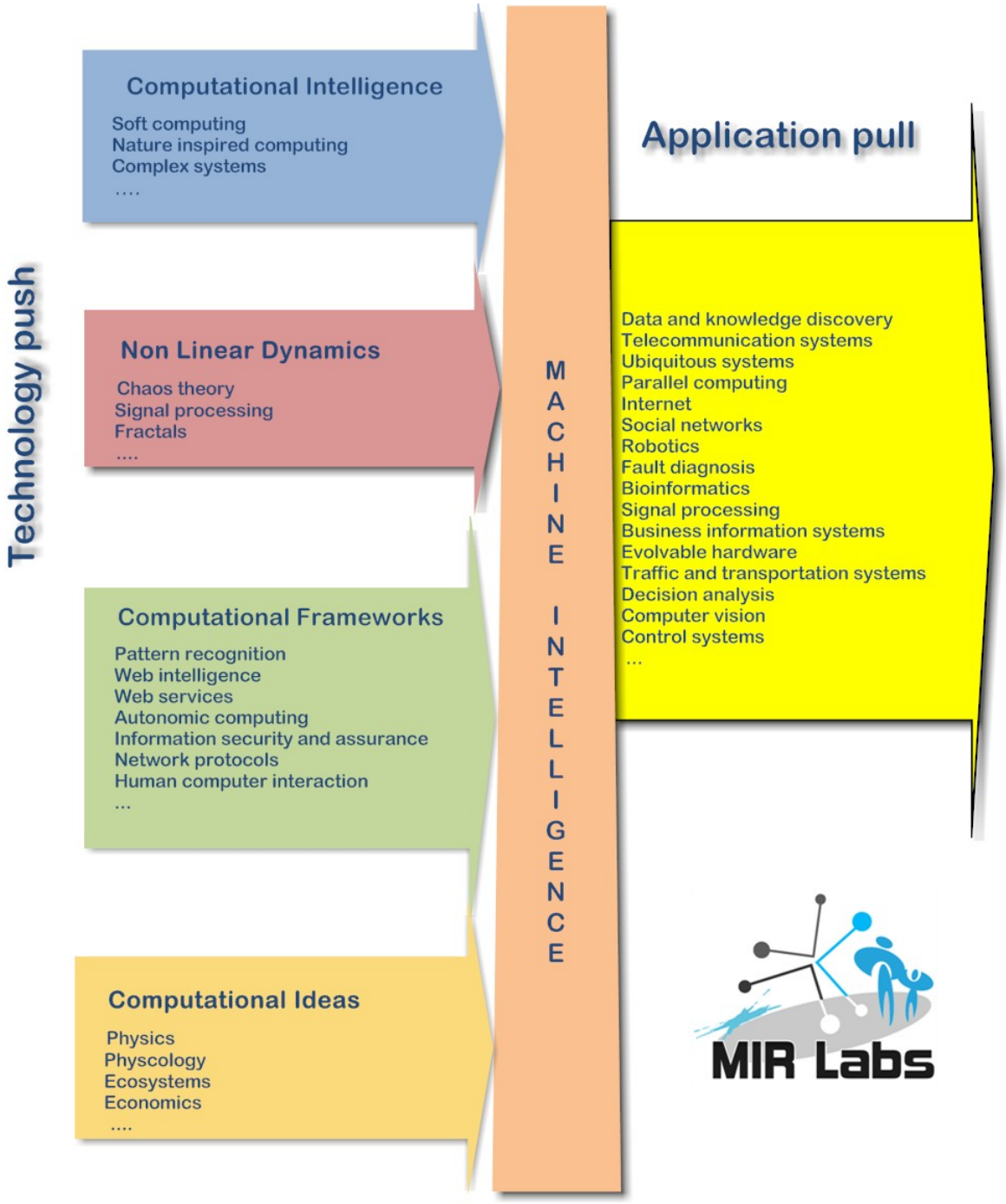
⇒ The challenge is to exploit the tolerance for imprecision by devising methods of computation which lead to an acceptable solution at low cost. This, in essence, is the guiding principle of modern intelligent computing.

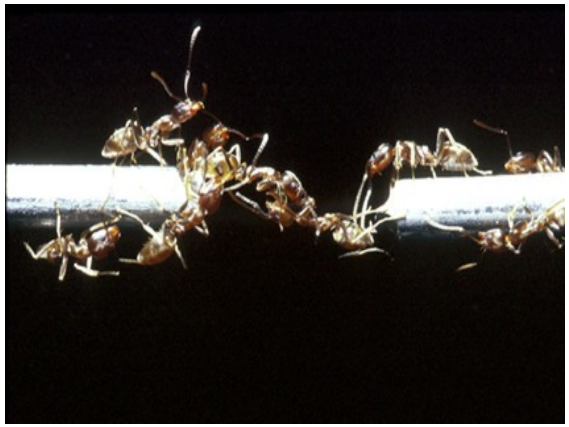
Traditional Approaches

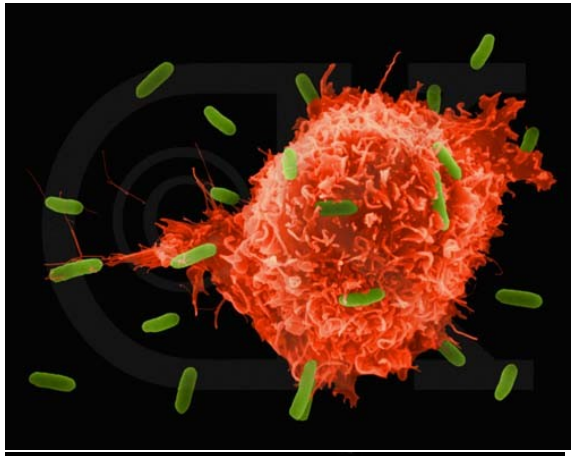
- Mathematical models, Black boxes, number crunching.
- Rule-based systems (crisp and bivalent): Large rule bases

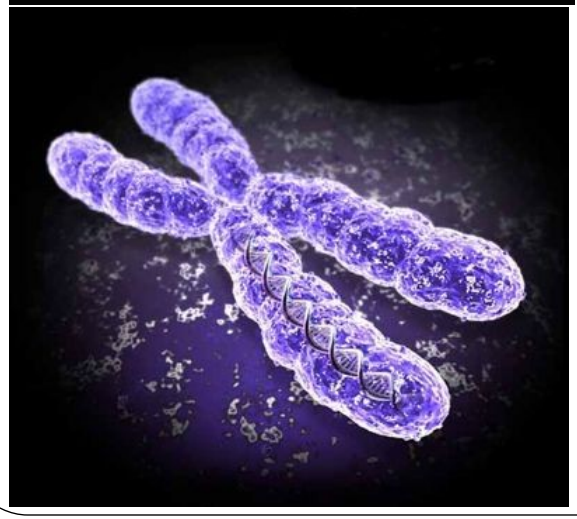
Smart Systems Features

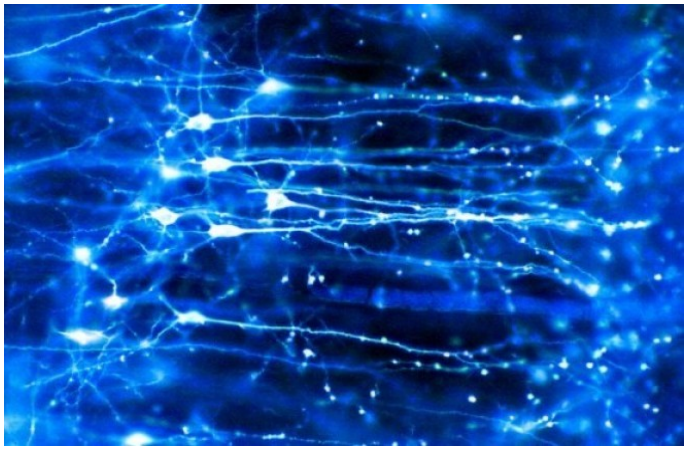
- Intelligence: System must perform meaningful operations
- Interprets information
- Comprehends the relations between the phenomena or objects
- Applies the acquired information to new conditions
- Flexible, Robust, Adaptive, Autonomous, Decentralized

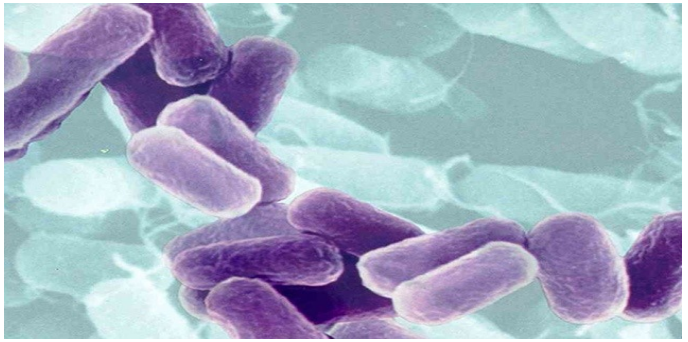

Technology push
Computational Intelligence
Soft computing
Nature inspired computing
Complex systems
....
Non Linear Dynamics
Chaos theory
Signal processing
Fractals
....
Computational Frameworks
Pattern recognition
Web intelligence
Web services
Autonomic computing
Information security and assurance
Network protocols
Human computer interaction
...
Computational Ideas
Physics
Physcology
Ecosystems
Economics
....
MACHINE INTELLIGENCE
Application pull
Data and knowledge discovery
Telecommunication systems
Ubiquitous systems
Parallel computing
Internet
Social networks
Robotics
Fault diagnosis
Bioinformatics
Signal processing
Business information systems
Evolvable hardware
Traffic and transportation systems
Decision analysis
Computer vision
Control systems
...
MIR Labs







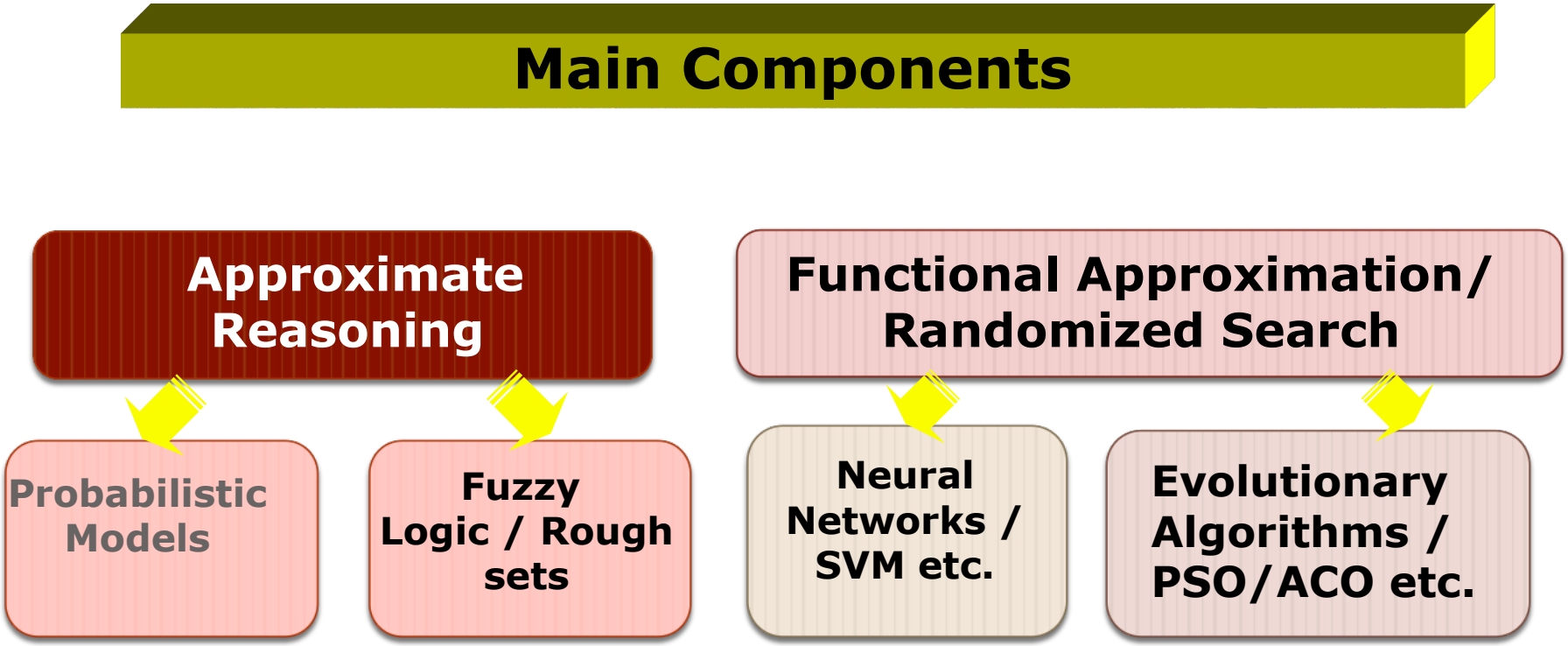




In nature it works…

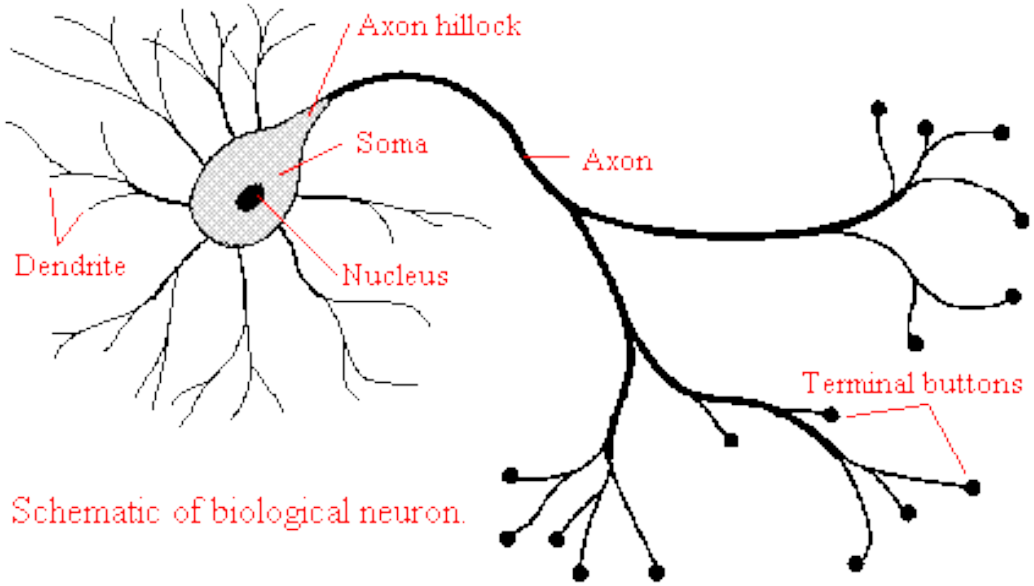
Why not for our digital ecosystem?

Smart Approach – Nature Inspired Computing



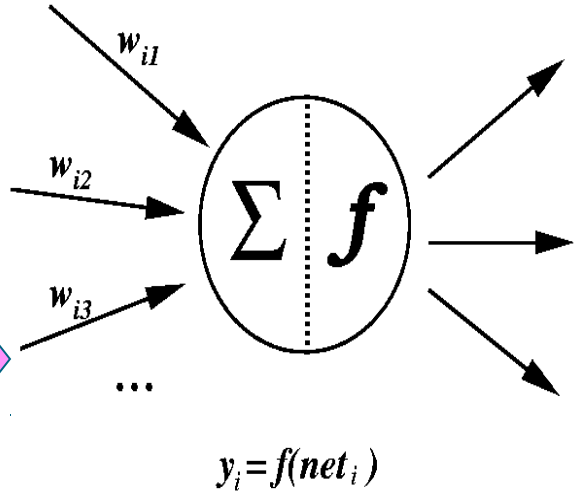
Artificial Neural Network

Mammalian neuron



Schematic of biological neuron.

Artificial neuron

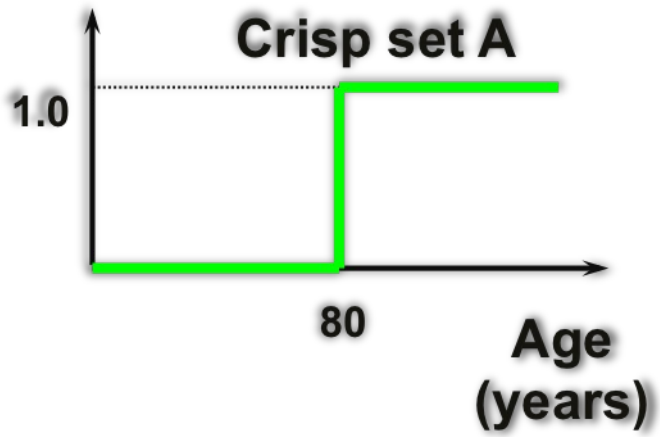


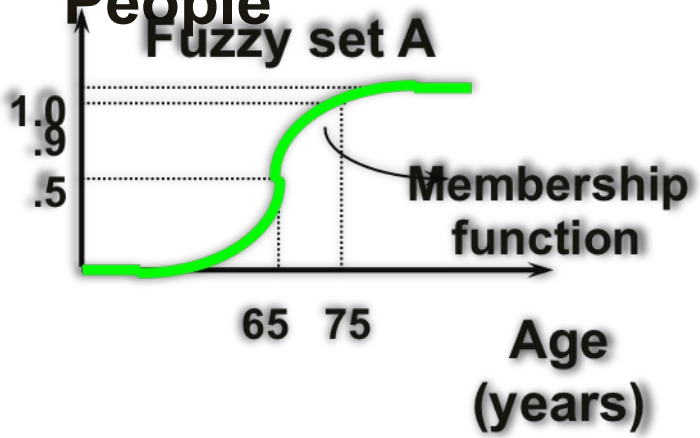
$$y_i = f(net_i)$$

Multi-Valued Logic --Jan Łukasiewicz

Fuzzy Logic

A = Set of Old People





Rough Set – Zdzisław Pawlak

The rough set concept overlaps—to some extent—with many other mathematical tools developed to deal with vagueness and uncertainty, in particular with the Dempster-Shafer theory of evidence.

Rough set does not compete with fuzzy set theory, with which it is frequently contrasted, but rather complements it.

One of the main advantages of rough set theory is that it does not need any preliminary or additional information about data, such as probability distribution in statistics, basic probability assignment in the Dempster-Shafer theory, or grade of membership or the value of possibility in fuzzy set theory.

Computational Theory of Perceptions

Humans have remarkable capability to perform a wide variety of physical and mental tasks without any measurement and computations.

Reflecting the finite ability of the sensory organs and (finally the brain) to resolve details, Perceptions are inherently imprecise.

Provides capability to compute and reason with perception based information

How to Model Perceptions

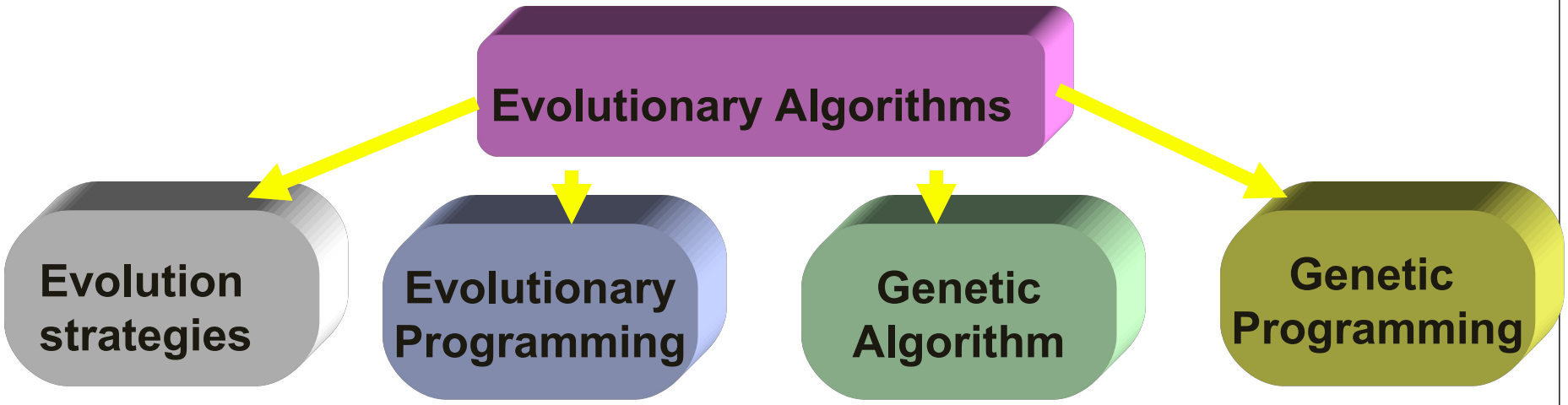
- Perceptions are both fuzzy and granular
- Boundaries of perceived classes are un-sharp
- Values of attributes are granulated

Example:

Granules in age: *very young, young, not so old,…*

Perceptions are described by propositions drawn from a natural language

Evolutionary Algorithms



Evolutionary Algorithms can be described by

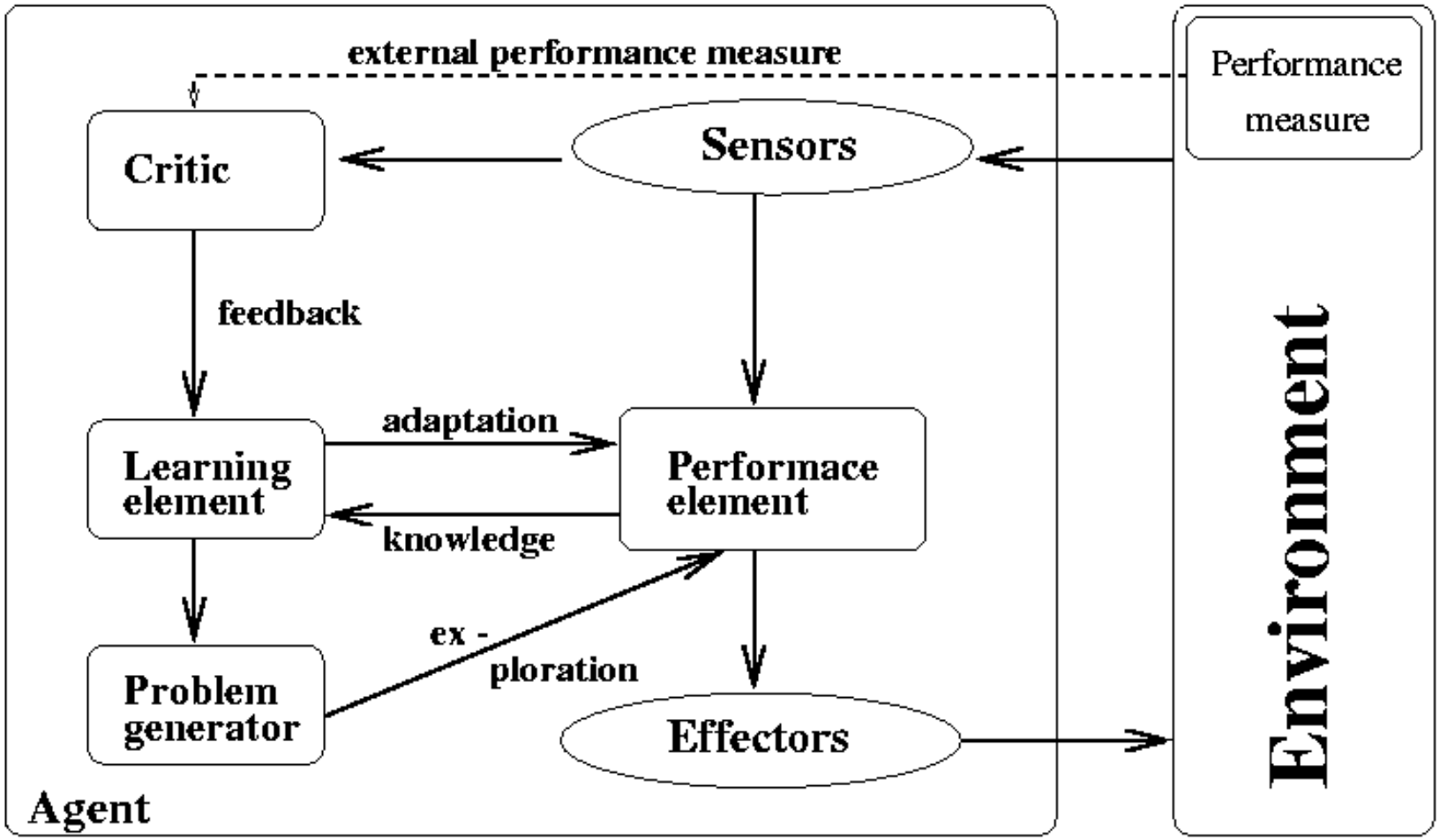
$$x[t+1] = s(v(x[t]))$$

$x[t]$: the population at time t under representation x

v : is the reproduction operator (s)

s : is the selection operator

Hybrid Approaches



Application Examples

Improving the delivery of health care in geriatric residences

The Problem..

Over the past 30 years, the number of Europeans over 60 years of age has risen by about 50 percent, and now represents more than 25 percent of the population.

Within 20 years, experts estimate that this percentage will rise to one-third of the population.

Creating secure, unobtrusive, and adaptable environments for monitoring and optimizing healthcare will become vital in the near future.

Alzheimer patients:

New patients arrive and others pass away ☹ While the staff rotation is also relatively high and they normally work in shifts of eight hours.

The Solution

Ambient Intelligence is the vision of an environment

- filled with smart and communicating devices
- which are naturally embedded in the environment and in common objects
- while their presence is kept as seamless as possible

When coupled with RFID, Wi-Fi technologies, and handheld devices, such systems offer many new possibilities.

Our system aims to support elderly and Alzheimer patients in all aspects of daily life, predicting potential hazardous situations and delivering physical and cognitive support.

The Environment

Alzheimer Santísima Trinidad Residence of Salamanca, Spain

The Residence is for **Alzheimer's patients** over **65** years old.

Its services and facilities include medical service, including occupational therapy and technical assistance

Comprises of: A terrace and a garden; laundry and tailoring services; a hairdressing salon; a chapel and religious services; a cafeteria and various rooms, including a geriatric bathroom, a multipurpose room, and separate rooms for reading, socializing, visiting with guests, and watching TV.

Technologies Used

Multi-agent system, which is a dynamic system for the management of different aspects of the geriatric center.

Radio Frequency Identification (RFID) technology for ascertaining patients' location.

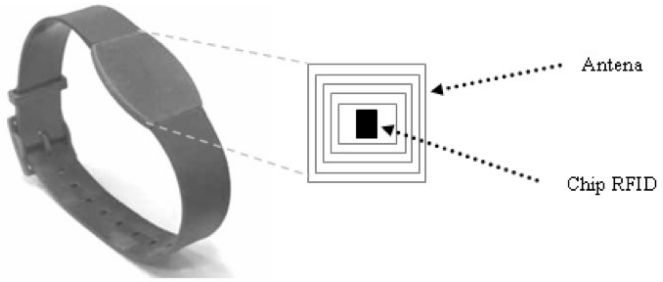
Mobile devices and Wi-Fi technology to provide the personnel of the residence with updated information about the center and the patients, to provide the working plan, information about alarms or potential problems and to keep track of their movements and actions within the center.

From the user's point of view the complexity of the solution has been reduced with the help of friendly user interfaces and a robust and easy to use multi-agent system.

Technologies Used

System uses microchips mounted on bracelets worn on the patient's wrist or ankle, and sensors installed over protected zones, with an adjustable capture range up to 2 meters.

The microchips or transponders use a 125 kHz signal to locate the patients, which can be identified by consulting the **software agents** installed in PDA's.



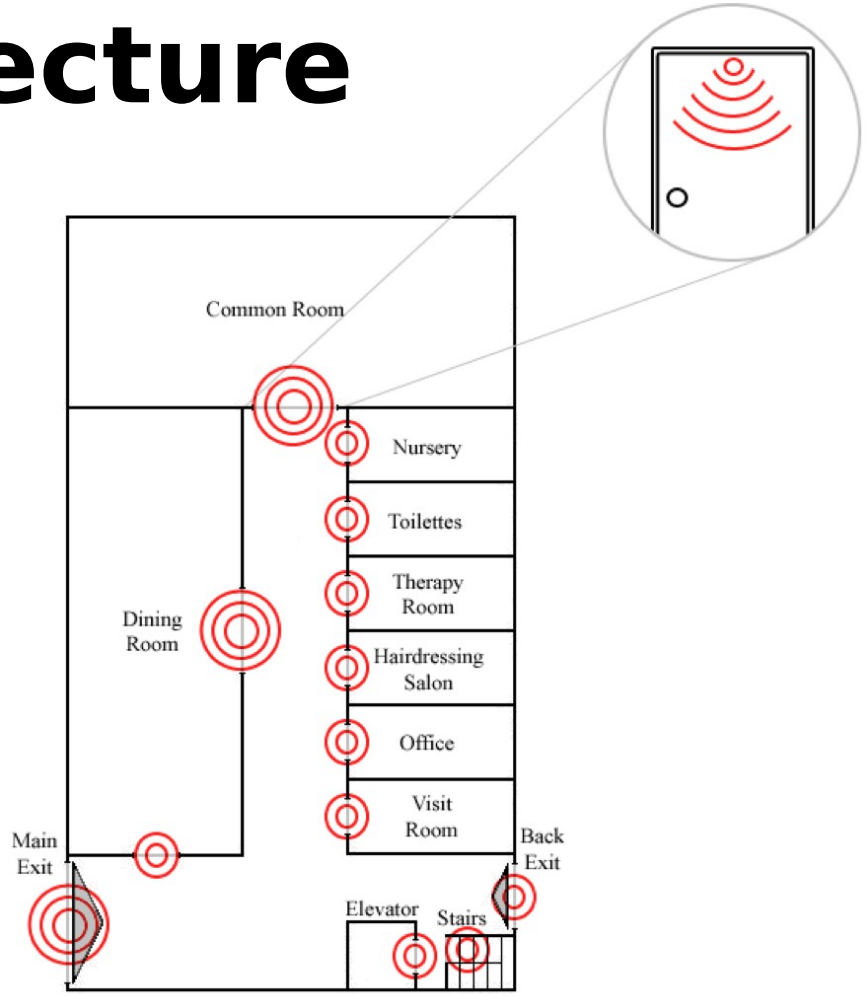
Software Architecture

Patient : monitoring, location, daily tasks, and anomalies

Doctor: treats patients

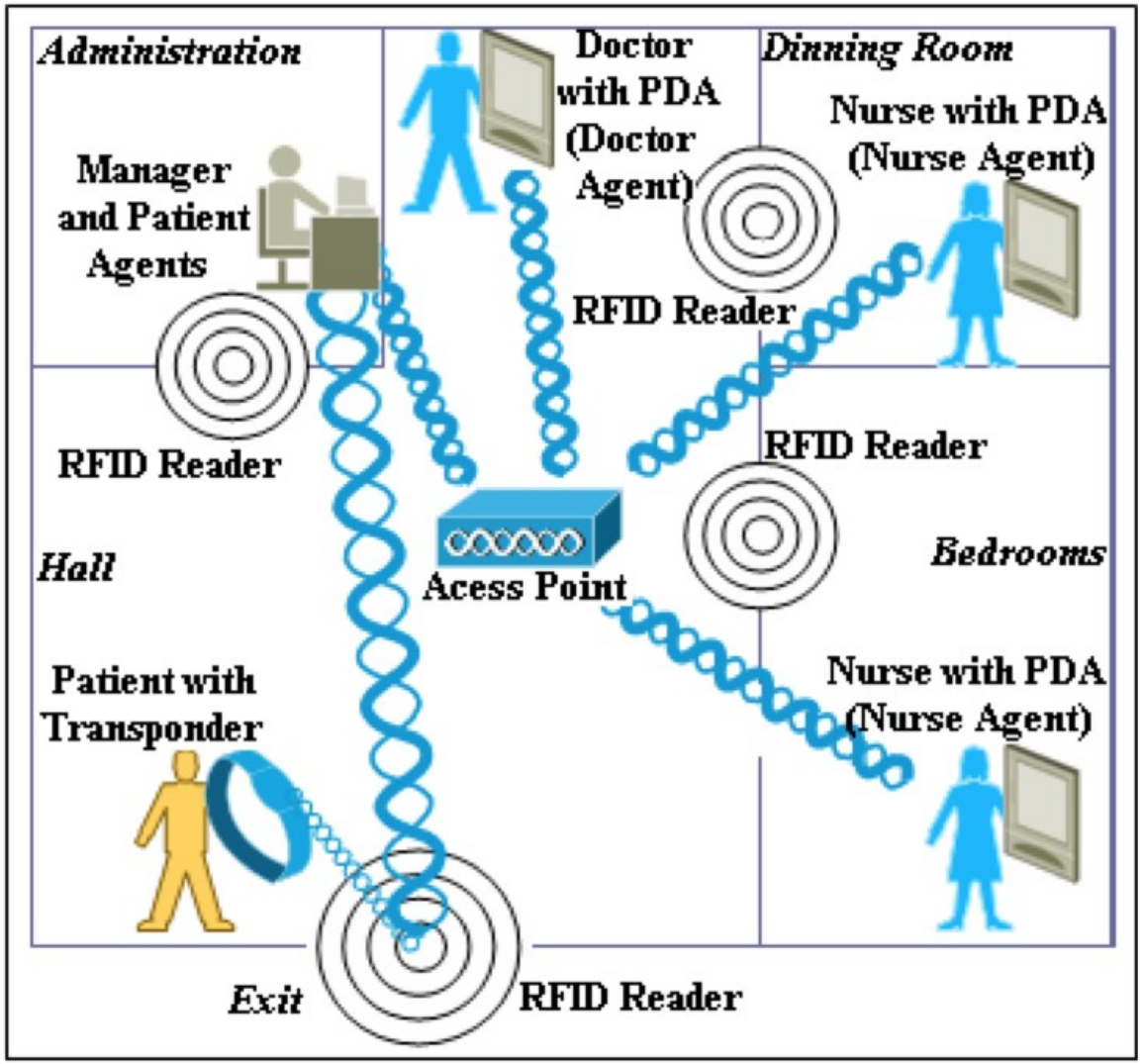
Nurse: schedules the nurse's working day obtaining dynamic plans depending on the tasks needed for each assigned patient

Security: controls the patients' location and manages locks and alarms



Manager: manages the medical record database and the doctor-patient and nurse-patient assignment

Software Architecture



Patient Agent

The beliefs that were seen to define a general patient state: weight, temperature, blood pressure, feeding (diet characteristics and next time to eat), medication, posture change, toileting, personal hygiene, and exercise.

The beliefs and goals for every patient depend on the plan or plans corresponding to the treatments or medicine that the doctors prescribe.

The patient agent must have periodic communication with the doctor and nurse agent.

Must ensure that all the actions indicated in the treatment are fullfiled.

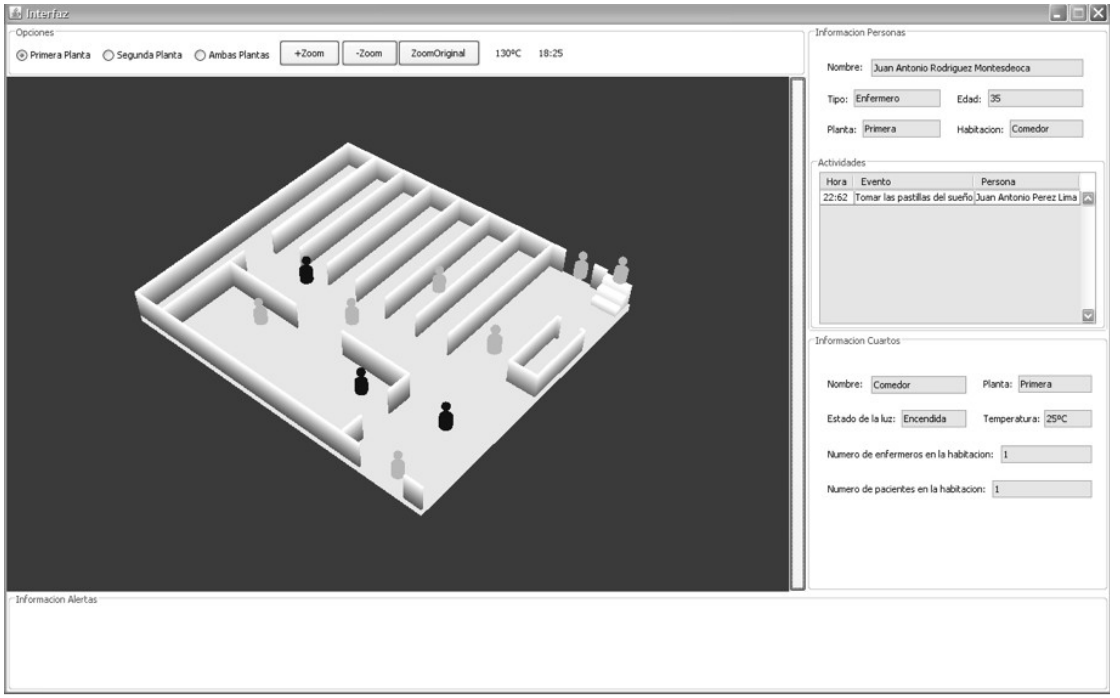
Agents Setup

Manager and Patient agents run in a central computer, but GerAg agents run on mobile devices, so a robust wireless network has been installed as an extension to the existing wired LAN.

With respect to the question of failure recovery, a continuous monitoring of the system is carried out. Every agent saves its memory (personal data) onto a data base. The most sensitive agents are patient agents, so these agents save their state every hour. When an agent fails, another instance can be easily created from the latest backup

System Interfaces

Nurse



Manager

How Effective?

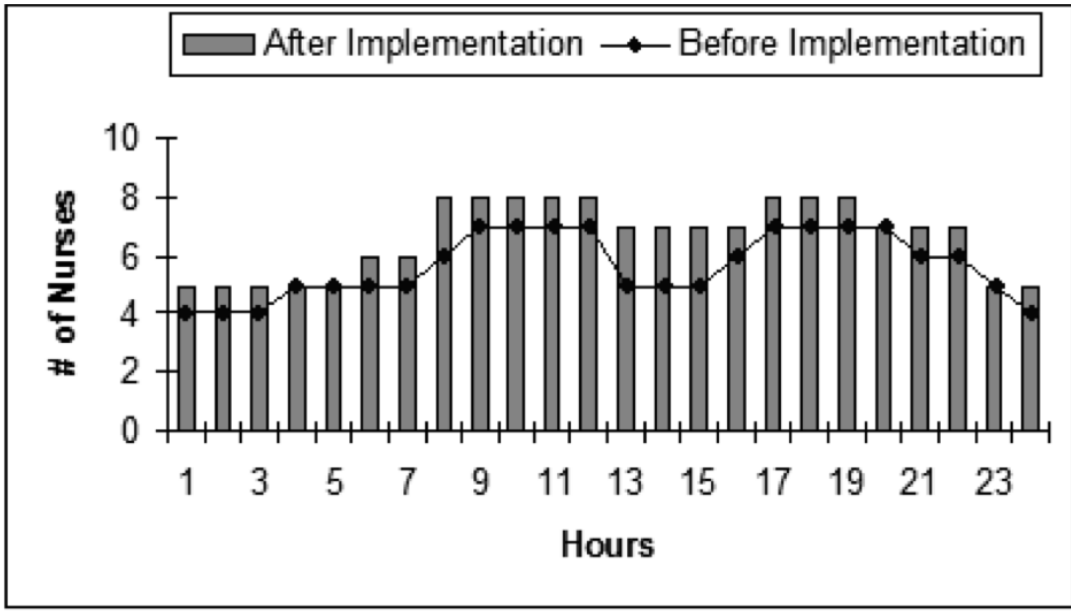


Table 1. Average direct-task times (in minutes) using GerAmi (Geriatric Ambient Intelligence) for patients with varying dependency levels.

Dependency degree	Cleaning	Feeding	Oral medication	Parenteral medication	Posture change	Toileting	Exercise	Other tasks
1	35	18	8	30	25	8	60	10
2	45	28	11	42	50	30	90	10

Table 2. Average indirect-task times (minutes) before and after GerAmi.

	Monitoring	Reports	Visits	Other	Total
Before GerAmi	167	48	73	82	370
With GerAmi	105	40	45	60	250

SHOMAS: Intelligent Guidance and Suggestions

Tormes Mall in Salamanca (Spain)

Shopping Guidance System

A shopping centre is a dynamic environment, in which shops change, promotions appear and disappear continuously, etc.

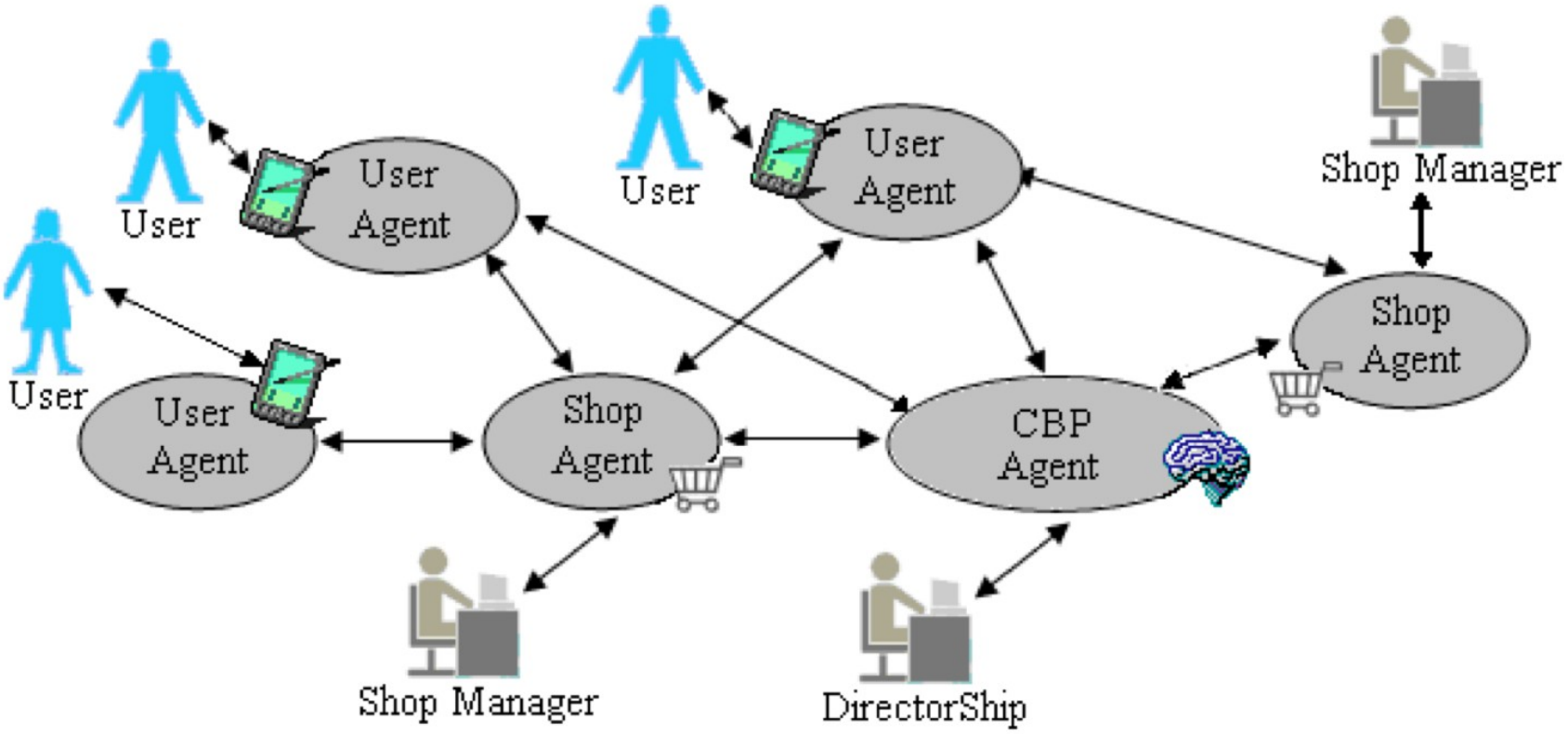
The proposed system helps users to identify a shopping or leisure plan as well as to identify other users within a given shopping mall.

Multiagent system that incorporates reactive and deliberative agents that take decisions automatically.

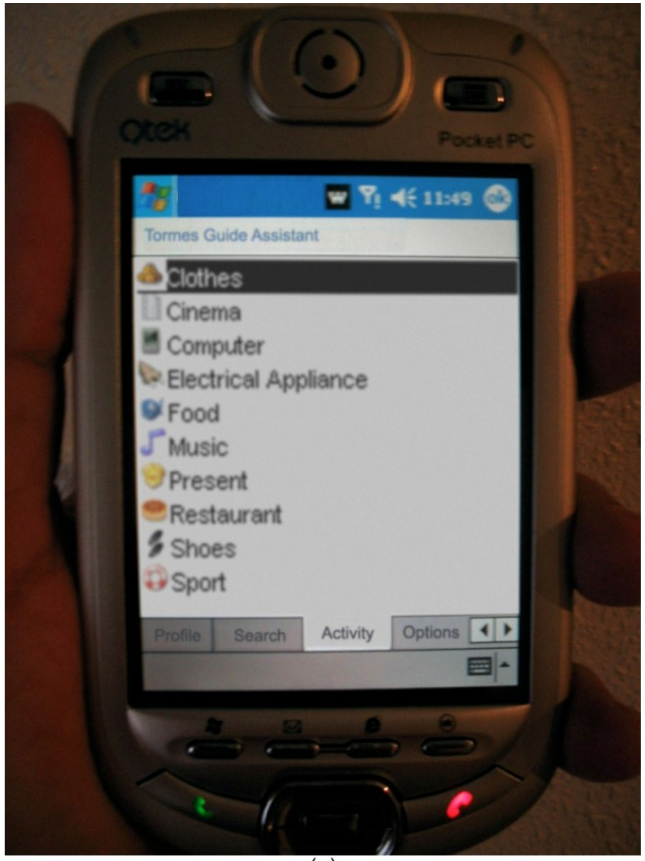
System Architecture

The system uses Radio Frequency Identification (RFID) technology to ascertain users' location in order to provide security and to optimize their time in the mall.

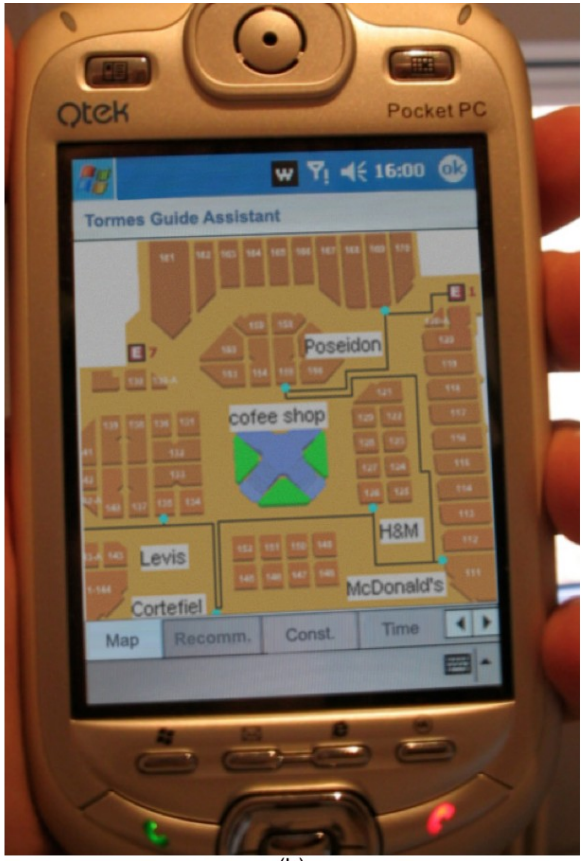
The software agent incorporates a Case Based Planning (CBP) engine which allows the agent to learn from initial knowledge, to interact autonomously with the environment and users, and allows it to adapt itself to environmental changes by discovering knowledge "know - how".


User
User Agent
User
User Agent
Shop Manager
User
User Agent
Shop Agent
CBP Agent
Shop Agent
Shop Manager
DirectorShip

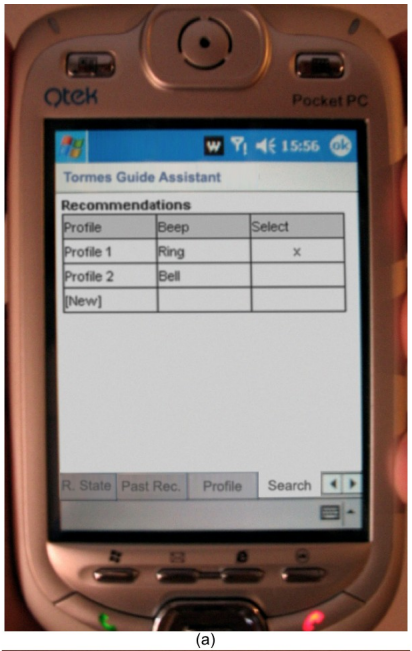
COMMUNICATOR
+
User Agent
+
1
FINDER
PROFILE MANAGER
PROMOTIONS MANAGER
1
Shop Agent
+
STORE OPERATOR
ANALYST
CLIENTS MANAGER
1
+
CBP Agent
1
+
PLANNER
INCIDENTS MANAGER


qtek
Pocket PC
11:49
Tormes Guide Assistant
Clothes
Cinema
Computer
Electrical Appliance
Food
Music
Present
Restaurant
Shoes
Sport
Profile
Search
Activity
Options

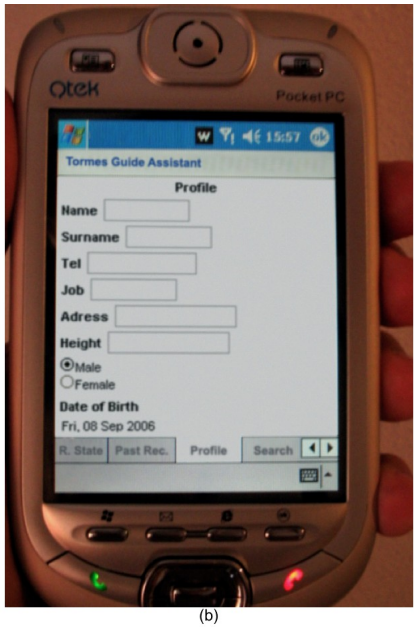
(a)


qtek
Pocket PC
16:00
Tormes Guide Assistant
Poseidon
cofee shop
H&M
Levis
McDonald's
Cortefiel
Map
Recomm.
Const.
Time

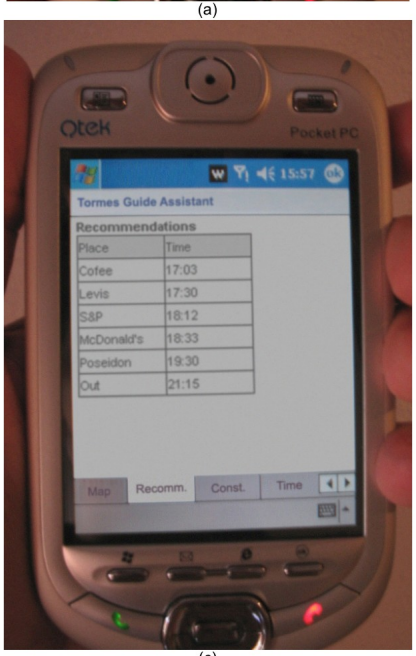
(b)


Qtek
Pocket PC
15:56
Tormes Guide Assistant
Recommendations
Profile | Beep | Select
Profile 1 | Ring | x
Profile 2 | Bell |
[New] | |
R. State
Past Rec.
Profile
Search

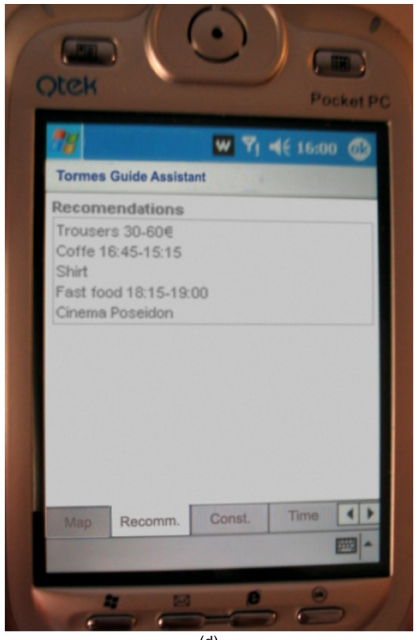
(a)


Qtek
Pocket PC
15:57
Tormes Guide Assistant
Profile
Name
Surname
Tel
Job
Adress
Height
Male
Female
Date of Birth
Fri, 08 Sep 2006
R. State
Past Rec.
Profile
Search

(b)


Qtek
Pocket PC
15:57
Tormes Guide Assistant
Recommendations
Place | Time
Cofee | 17:03
Levis | 17:30
S&P | 18:12
McDonald's | 18:33
Poseidon | 19:30
Out | 21:15
Map
Recomm.
Const.
Time

(c)


Qtek
Pocket PC
16:00
Tormes Guide Assistant
Recomendations
Trousers 30-60€
Coffe 16:45-15:15
Shirt
Fast food 18:15-19:00
Cinema Poseidon
Map
Recomm.
Const.
Time

(d)

How Can We Teach Things to Computers?

In order for a program to be capable of learning something, it must first be capable of being told it.

John McCarthy

We Divide Things Into Concepts

Easy: If dogs are mammals and mammals are animals, are dogs mammals?

Difficult: If most Canadians have brown eyes, and most brown eyed people have good eyesight, then do most Canadians have good eyesight?

Limitations of the Human Mind

- Naming of colors. Based on learning, not on absolute standards.
- Face recognition. Cannot be passed on to another person by explanation.
- Object recognition. People cannot properly explain how they recognize objects.

Conclusions

- **Managing Complexity:** Can autonomy be planned? Can decentralization be controlled? Can evolution be designed?

- **Safety and Security: T**he safety and security of a nation, its people and its place in the global market is becoming more difficult.

. **Culture, media, ethics:** Movies, television, cell phones, computer games, and the internet have all, in one way or another, collapsed the local into more international, creating a blur of perceptions, dreams and social mores.

Thank You -

Dziekuje

ajith.abraham@ieee.org