**Five ongoing trends of Computing**

**1. Ubiquity:** Pervasive computing, also called ubiquitous computing, is the growing trend of embedding computational capability (generally in the form of microprocessors) into everyday objects to make them effectively communicate and perform useful tasks in a way that minimizes the end user's need to interact with computers.

**2. Interconnection:** Networked into a large distributed system.

**3. Intelligence:** Simulation of human intelligence processes by machines.

**4. Delegation:** Judgment of computer systems are frequently accepted.

**5. Human-orientation:** Use concepts and metaphors that reflect how we understand the world

**Agent**

An agent is a computer system capable of autonomous (Independent, has control over its state) action in some environment.

**Properties (Weak Characteristics)**

**1. Autonomy:** agents operate without the direct intervention of humans or others, and have some kind of control over their actions and internal state.

**2. Pro-activeness:** agents do not simply act in response to their environment, they are able to exhibit goal-directed behavior by taking the initiative.

**3. Reactivity:** agents perceive their environment and respond in a timely fashion to changes that occur in it.

**4. Social ability:** agents interact with other agents (and possibly humans) via some kind of agent-communication language.

**Agent vs Object**

An object does not encapsulate behavior: it has no control over the execution of methods. In case of agents, they request other agents for performing actions rather than invoking them directly. The decision about whether to act upon the request lies with the recipient.

**Main differences:**

Degree of autonomy, Degree of smartness, Degree of activeness

**Properties (Strong Characteristics)**

**Veracity:** agent will not knowingly communicate false information.

**Benevolence:** agents do not have conflicting goals and always try to do what is asked of it.

**Rationality:** an agent will act in order to achieve its goals and will not act in such a way as to prevent its goals being achieved.

**Mobility:** the ability of an agent to move around a network.

**Two key problems of agent**

Micro Aspect: Independent, autonomous action

Macro Aspect: Interaction with other agents

**Distributed Artificial Intelligence (DAI)**

Main areas of DAI

1. Multi-Agent Systems (MAS): designed in a decentralized way with great part of independency and autonomy. Agents with individual preferences will interact in particular environments such that each will consent to act in a way that leads to desired global goal.

Types: Cooperative, Self-interested

2. Distributed Problem Solving (DPS): Task decomposition. Considers how the task of solving a particular problem can be divided among a number of modules that cooperate in dividing and sharing knowledge about the problem and its evolving solution(s).

Emergence

Global (macro level) behavior, patterns and properties that are arising from the interactions between local parts of the system (micro level).

Swarm Intelligence

Multi-robot systems, which implement or adapt the concept of emergent behavior, are commonly referred to as swarm robotic systems.

Self-Organization

Self-organization is a dynamical and adaptive process where systems acquire and maintain structure themselves, without external control. The intuitive and regularly used approach to realize self-organization is applying the concept of feedback loops.

Self-Organization and Emergence

Self-organizing and emergent systems as distinct concepts, they still have one thing in common, that is: There is no explicit external control whatsoever.

The main difference between self-organization and emergence is that in the case of self-organization, individual entities can be aware of the system's intended global behavior. In consequence, self-organization can be seen as a weak form of emergence.

Agent Negotiation: conflict resolution

Agent Coordination: achieving coherent (consistent) behavior

Agent Communication: interoperability (exchange and make use of information)

Components of a system for effective interaction and interoperability

1. Common language

2. Common understanding of the knowledge exchanged

3. Common interpretation of the knowledge

4. Ability to exchange whatever is included in the previous items

Multi-Agent System Architectures

The infrastructure for a MAS can be defined as a set of services, conventions and knowledge that support complex social interactions (e.g. negotiations, agree on commitments/coordination).

Software Engineering of Multi-Agent: Agent Oriented Software Engineering (AOSE)

Successful industrial deployment of agent technology requires techniques that reduce the risk inherent in any new technology. Two ways that reduce risk in the eyes of potential adopters are:

1. Present the new technology as an incremental extension of known and trusted methods.

2. Provide explicit engineering tools that support industry-accepted methods of technology deployment.

Agent architectures

Deliberative, Reactive, Hybrid

Basic negotiation categories

1. Negotiation language category

2. Negotiation decision category

3. Negotiation process category

Negotiation Components

Any negotiation setting will have 4 components:

1. Negotiation set: represents the space of possible proposals that agents can make

2. Protocol: defines the legal proposals that agents can make

3. Collection of strategies: (one for each agent) determines what proposals the agent will make

4. Rule: to determine when an agreement has been reached