

SOFTWARE AGENTS: AN OVERVIEW

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Abstract: Software agents are part of Artificial intelligence domain. These agents are software entities capable of working autonomously. They can sense or receive input from their environment, act on it and can make changes in their environment leading to different kinds of automation required in processes and devices. Intelligent software agents have already grabbed their roots in internet and web based services where they act as background workers, collecting information, processing it and taking actions on behalf of user or for facilitating users. This paper explores software agents, their capabilities and their application areas in detail.

Key Words: Software agents, Intelligent agents, Mobile agents

1. Introduction: Software agents are piece of software or a combination of hardware or software capable of sensing input from their environment and performing actions to make changes in their environment or to achieve their stated objectives without human intervention. Software agents are often confused with objects in object oriented programming however they are different from them as they possess autonomy for decision making which objects don't have. Objects work whenever they are told to do so however agents sense their environment and react to changes taking place in their environment, sometimes they even act proactively to bring changes in their environment.

Agents are actually artificially intelligent piece of code which have embedded code to make them capable of sensing input from the environment of their placement, they can react to the input received or can take initiatives to change it by themselves. Agents also possess social abilities to communicate with other agents existing in the environment, they may cooperate with them to provide extended services to end users. Most importantly, agents have ability to learn from behavior/actions of their user and they adapt themselves as per their user's choice. Thus, agents improve their performance with passage of time. Characteristics of agents may be classified as follows:

Primary Characteristics

- ❖ **Autonomous-** An agent should be able to execute without the need for human interaction, although intermittent interaction may be required.
- ❖ **Social / Communicative-** An agent should have a high level of communication with other agents. The most common protocol for agent communication is the Knowledge Query and Manipulation Language (KQML) [135].
- ❖ **Reactive / Responsive-** An agent should be able to perceive its environment and react to changes in it.

Secondary Characteristics

- ❖ **Proactive-** Proactive agents do not just react to their environment but can take active steps to change that environment according to their own desires.
- ❖ **Adaptive-** Adaptive agents have the ability to adjust their behavior over time in response to internal knowledge or changes in the environment around them.
- ❖ **Goal-oriented / Intentions-** These agents have an explicit internal plan of action to accomplish a goal or set of objectives.
- ❖ **Persistence / Continuous-** Persistent agents have an internal state that remains consistent over time.
- ❖ **Mobility-** Mobile agents can proactively decide to migrate to a different machine or network while maintaining persistence.

Tertiary Characteristics

- ❖ **Emotion-** Agents with the ability to express human-like emotion or mood. Such agents might also have some form of anthropomorphic character or appearance.
- ❖ **Intelligence -** Agents with the ability to reason, learn and adapt over time.
- ❖ **Honesty-** Agents that believe in the truthful nature of the information they pass on.

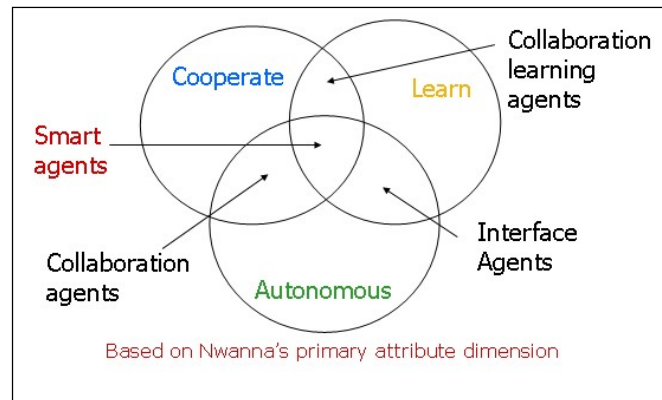
Not all agents are possessed with all above features. On the basis of features possessed by an agent, agents may be distinctly classified. Next section provides classification of agents on the basis of their features:

2. Classification of Agents:

1. **Interface Agents:** Interface agents are possessed with learning ability and autonomy. Interface agents perform various tasks for their owners using these abilities. These agents observe the actions being carried out by the user and tries to learn about those tasks and assist the user with those tasks in future. Interface agents learn to better assist its users in four ways [8]:
 - By observing and imitating the user
 - Through receiving positive and negative feedback from the user
 - By receiving explicit instructions from the user

- By asking other agents for advice While interface agents ask other agents for advice (learning from peers), their cooperation with other agents however, is limited.
2. **Collaborative agents:** these agents have the ability to work in collaboration with other agents. Through collaboration with other agents, these agents can provide services beyond their capabilities.
 3. **Information / Internet agents:**The explosive growth of information on the World-Wide Web has given a rise these agents.These agents will be able to help us manage, manipulate, or collate information from many distributed resources [7].

Figure 1 given above indicates different types of agent formation with their attributes.



4. **Reactive Agents** act and respond in a stimulus-response [18] manner to the present state of the environment in which they are embedded. P. Maes highlights the following three key ideas which underpin reactive agents [13].
 - Emergent functionality: the dynamics of the interaction leads to the emergent complexity.
 - Task decomposition: a reactive agent is viewed as a collection of modules which operate autonomously and responsible for specific tasks (e.g. sensing, computation, etc.).
 - They tend to operate on representations that are close to raw sensor data.
 5. **Hybrid Agents** refer to those agents whose constitution is a combination of two or more agent philosophies within a singular agent [4]. These philosophies may be mobile, interface, information, collaborative, ... etc. The goal of having hybrid agents is the notion that the benefits accrued from having the combination of philosophies within a single agent is greater than the gains obtained from the same agent based on a singular philosophy. An example of this is collaborative interface agents [17].
 6. **Mobile Agent:**A software agent is a mobile software agent if it is able to migrate from host to host to work in a heterogeneous network environment. When it reaches the new host, the agent should be able to perform appropriately in the new environment. Since their inception, agent technology have been used in different tasks of diverse nature and proved to be beneficial. Next section presents some application areas of intelligent software agents.
- 3. Applications of Intelligent software agents**
- i. Collaborative agents are widely used in Distributed sensor networks and air traffic control
 - ii. Information extraction and processing in Semantic Web
 - iii. Serve as Personal digital assistants for email monitoring, schedule planning etc.
 - iv. Web personalization tools
 - v. Crawlers for Search Engines

4. Conclusion

Intelligent software agents have already been used in many domains such as semantic web for information extraction and processing, wireless sensor networks and cloud computing etc. They have proved to be beneficial in web based applications where autonomous functioning is desired. They work as background workers to achieve goals of their users. They have large potential for usage in complex applications which still needs to be explored.

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