Architecture of Internet Agent with Social Awareness

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Abstract
We describe approach, architecture, implementation and practical applications of personal software agent with social awareness, capable to capture socio-temporal context of its user on the Web and in social networks in the course of interactions of the user with agent itself and user's Internet environments online.

Keywords: cognitive architecture, personal agent, social awareness, social network

1 Introduction

Importance of social phenomena study and accounting for them in development of complex systems driven by artificial and collective intelligence gets more and more important from day to day. Rapid emergence of markets of autonomous devices and so-called *smart things* gets human users more and more dependent upon decisions made by software running these devices. Effectively, that software runs algorithms of artificial intelligence and machine learning, in certain cases relying on collective intelligence collected from personal *big data* assets growing online. Moreover, the importance of social phenomena gets applicable for every level of biological and social systems. The very recent works show effective social behavioral patterns even at metabolic level [1]. Earlier works render how principles of social organization enable efficient construction and development of multi-agent environments at the levels of technological and financial systems and ecosystems [2]. Classic works outline social impacts on decision making process for every individual person in society [3].

From practical perspective, impact of social context can be tremendous involving huge volumes of human population in very short time intervals [4]. Recent studies outline possible complexity of social interactions driving these impacts and so importance of study of them and accounting for them in practical work can be hardly overestimated [5]. In our work on *Aigents* project [6], we target to create personal software agent capable to make online experiences of the user more safe, comfortable and efficient. We realize this can't be done without of complete account of social context of the user including user's sources of information online as well as user's interactions in social networks.

2 Approach and Architecture

Overall approach for the development of software agent serving its human user is described in our earlier works [7], [8]. In short, we assume that the data perceived, processed and produced by such agent is bound to 3-dimensional spatial temporal attentional continuum. Hence, three key dimensions of the data are the time specific to experience of the data, social context of the data and the attention allocated to the data at given point of time in such context. First, temporal dimension reflects time frame of the data importance for agent and its user. Further, social context indicates importance of the data related to social environment of agent's user – including producers and consumers and of the data and ones related to the data in other ways, such as providing evaluations of the data such as positive or negative valuations, confirming its trustability and validity, etc. Finally, attentional dimension reflects extent to which data is important to the agent and its user at the moment to keeps it in *long-term* or *short term* areas of agent's memory based on that.

Agent Architecture

Overall agent architecture in *Aigents* system incorporates basic principles of development of cognitive functional systems accordingly to B. Goertzel [9] and E. Vityaev [10]. Its original design is described in one of our earlier works [11]. Latest design also includes components required to support dealing with the spatial temporal attentional continuum mentioned above (Fig. 1). That is, *Social Feeder* component is added to deal with social context. Then, *Archiver* layer is added to *Storage* to deal with attentional focus representing *long term* and *short-term* memories respectively. At last, there is *Thinker* layer included to implement associative learning, reasoning, clustering and categorization.

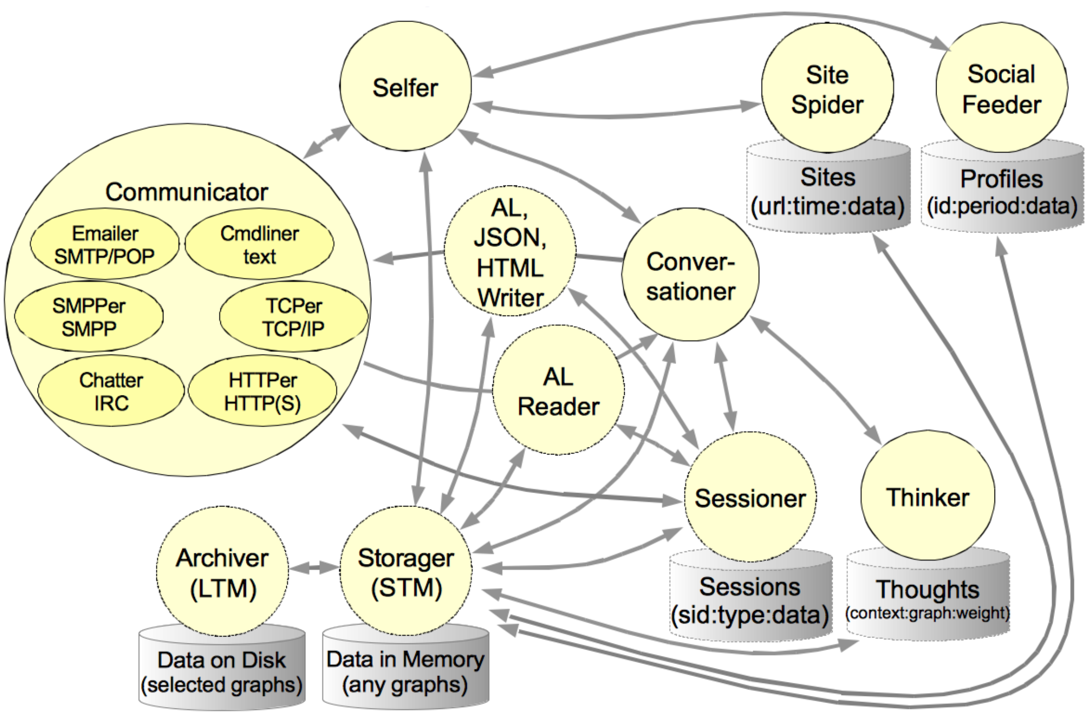

Figure 1: Architecture of *Aigents* system with Social Feeder, Archiver and Thinker components added.

Cognitive Pipeline

In extension to overall architecture, since the previous implementation [11], major effort has been spent to implement so called "cognitive pipeline" which incorporates five levels of processing – *gather*, *recognize*, *analyze*, *synthesize* and *present,* in short – *GRASP* (Fig. 2).

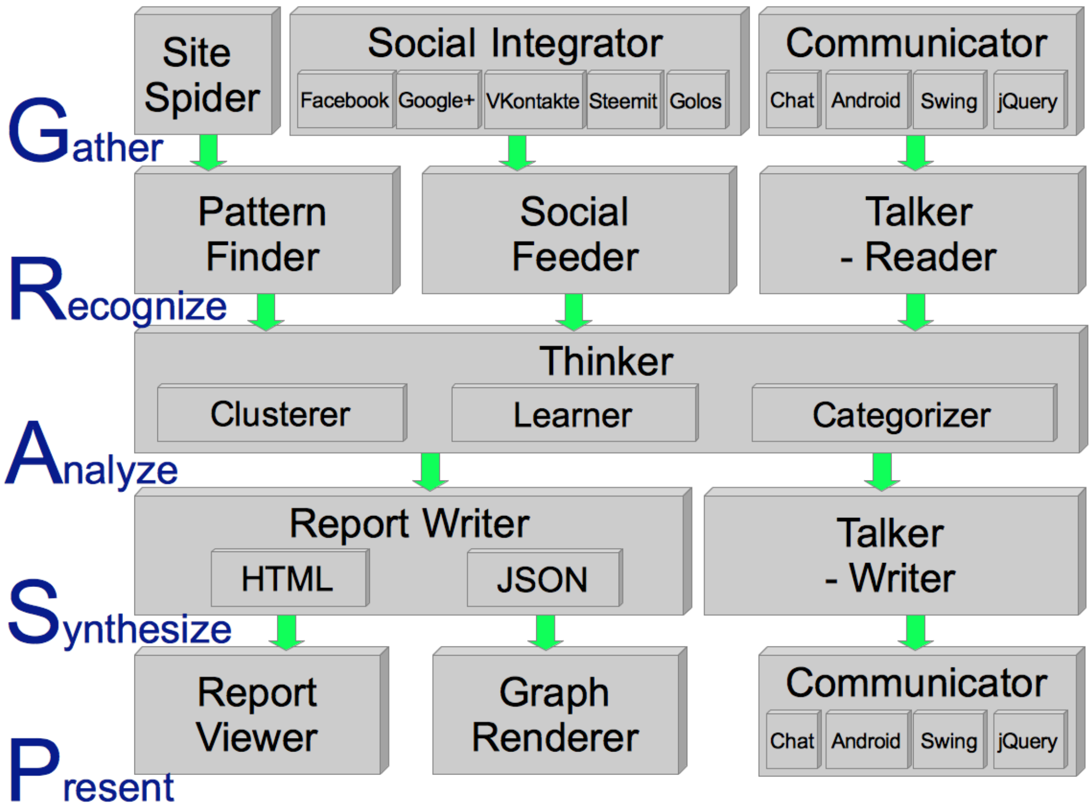

Figure 2: *Aigents* system cognitive pipeline for *gather*, *recognize*, *analyze*, *synthesize* and *present*.

The *Gather* layer of the pipeline contains pre-existing components to deal with collection of Web pages (*Site Spider*) and perceiving interactive input (*Communicator*) from user in form of chat messages or interactions on graphical user interfaces on Android systems, desktop and servers (with Java Swing user interface library) or within Web pages in browsers (with JavaScript jQuery library). For chat messages, there are adapters to implement conversations in modern chat messenger platforms such as Facebook Messenger and Telegram. Now, this layer also includes new *Social Integrator* component which operates adapters for interacting with major social networks – well known ones such as Facebook, Google+ and VKontakte or modern ones based on block-chain technology such as Steemit and Golos.io.

The *Recognize* components layer get inputs from respective components on the upper layer – *Pattern Finder* extracts entities and relationships from Web pages [12] while *Talker-Reader* comprehends chat messages and events in user interface. Novel *Social Feeder* component now is in charge to process unified feeds, comments and likes or votes specific to interactions in social networks. Upon processing, it produces integrated internal representation of activity of given social network user itself and events taking place in social environment of the user [13,14] to pass it further through the pipeline.

On the *Analyze* layer, new *Thinker* component now is in charge to derive associative relationships between the users, Web pages, relationships and entities found on these pages and social network events connecting all of them – by means of existing machine learning techniques [10, 12].

The *Synthesize* layer contains pre-existing *Talker-Writer* component intended to produce chat message texts and events in user interface accordingly to context of entities and relationships present in the *Thinker* layer. New *Report Writer* component now is in charge to transform internal social and thematic contexts from the layers above into comprehensible structured information in form of renderable HTML objects or parseable data in JSON format – which is generated in context of current temporal and attentional focus specific to interactions with user.

The latest layer facing the user is intended to *Present* information. As in earlier version, it can be done in form of either chat text messages or graphical user interface updates and events – with help of *Communicator* component, which can take place in native Aigents chat console or Facebook Messenger or Telegram chat sessions or within user interfaces on Android devices, desktop Java applications with Swing library or Web applications powered by JavaScript jQuery. Now, in Web version on https://aigents.com/ site, the latest *Report Viewer* component enables rendering HTML reports while Graph Renderer presents visual graphs of entities and relationships.

3 Practical Applications

For practical purposes of software agent implementing the architecture described above, there are two immediate practical applications. First, it can be useful for user itself and for its agent to comprehend true social environment around the user [13,14]. For instance, in can involve figuring out topics of interests, opinion leaders and authorities, true friends and most collaborative colleagues, fans and followers, persons and communities sharing the same areas of interests (Fig. 3). Moreover, all of the above can be done within historical perspective with different levels of precision.

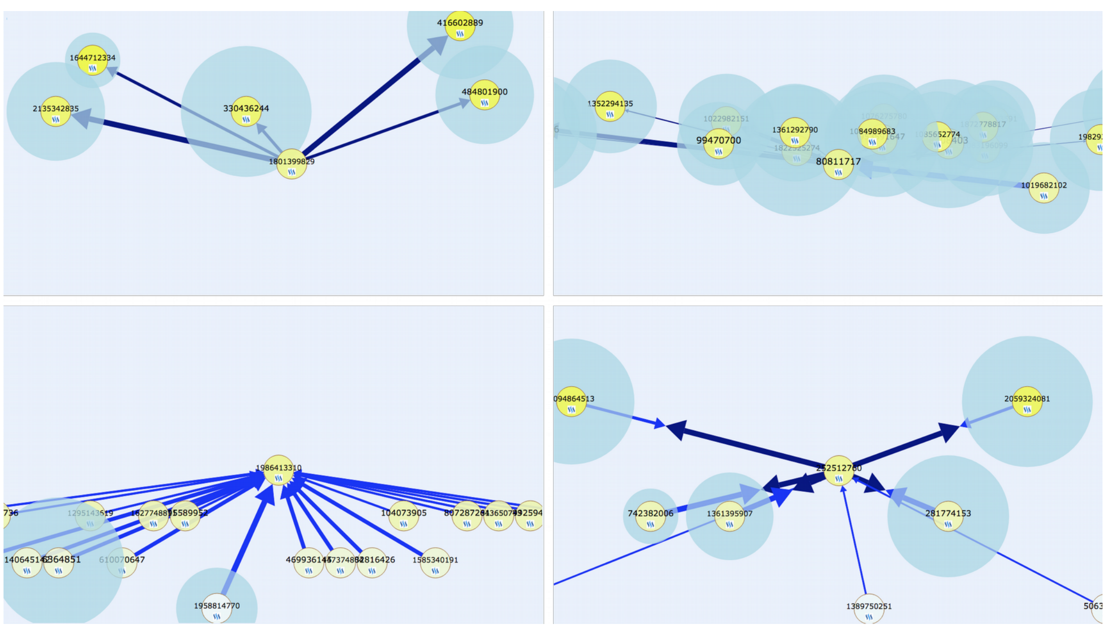

Figure 3: Examples of four different social expressions specific to four different individuals in Steemit social network in the *Graph* view of Aigents Web application online at https://aigents.com/.

For instance, on Fig.3 there are social graphs of four different anonymous individuals shown. Data on the graphs is taken from public social network Steemit, which is based on block-chain technology and hence all of the data is effectively public. However, to ensure privacy protection, we have obfuscated the data so real user ids are replaced with meaningless numbers. The node representing primary person, who is the owner of the social environment on the graph is placed in the center. Other nodes are representing people in social environment of primary person. *Halo* circles around them are indicating proximity of these people to primary person from perspective of closeness of their areas of interest. Lengths of arrows between nodes correspond to ratio of incoming versus outgoing communications. Widths of arrows represent relative intensity of interactions.

As it can be seen on Fig.3, there are four clearly different cases of social expression of four individuals detected. On the top-left, there is a *follower*, with many opinion leaders, sharing interests with most of them. On the bottom-left, there is an *opinion leader*, with many silent followers with few of them expressing similarity of interests. On the top-right, there is a *perfect peer*, with many connections and nearly symmetric interactions with all of them. On the bottom-right, there is a person with rich and diverse communication environment, possessing couple opinion leaders with shared interests, few peers with the same interests and several silent followers.

Another case of application of such agent is balanced news relevance assessment based on personal and social experiences both. One of the functions of the agent that we are developing is to extract new information of the user's interest appearing on the Web pages and deliver it to user. In order to do it in more precise way, the agent learns from user's feedback and remembers which news items user liked in the past experiences – we call it *personal relevance*. However, this might be not always sufficient. So the agent is using experiences from the other users in the social environment – we call it *social relevance*. With the two kinds of relevance measure for every news item, it is possible to derive *blended relevance* and present synthesized information to user. For instance, on the Fig. 4, the width of left part of the bar above every news item corresponds to *personal relevance*, while the width of right part of the bar corresponds to *social relevance*, making the blended value more reliable.

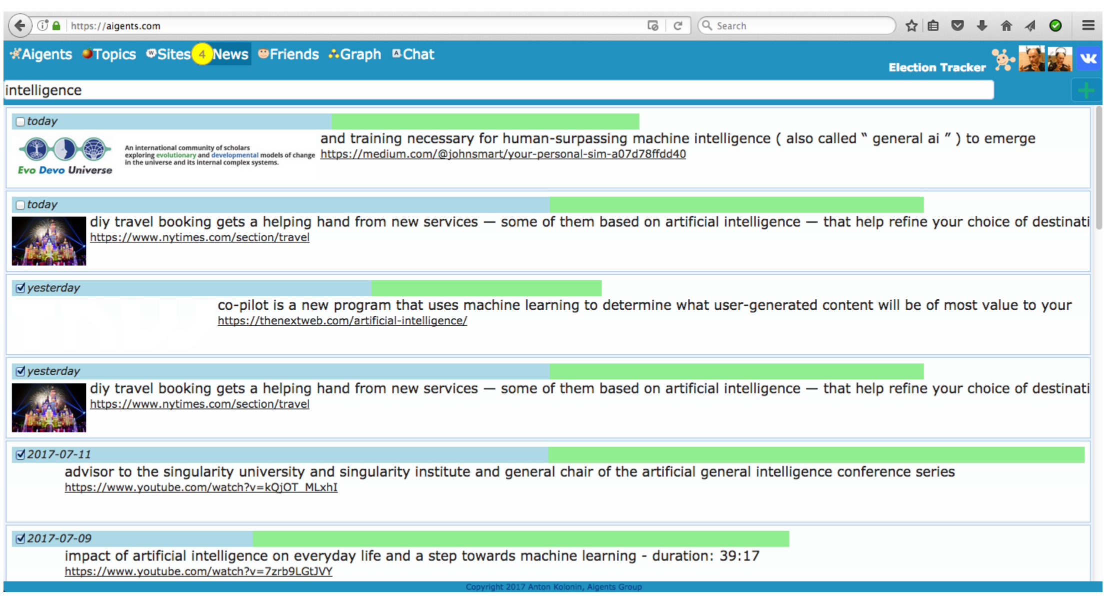

Figure 4: Representing news relevance measure as blended personal and social relevance (as left part and right part of the horizontal bar above the news item text, respectively) in the *Graph* view of Aigents Web application online at https://aigents.com/.

4 Conclusion

The approach and architecture described above has proved its applicability and usability in the course of testing with audience of 400 users, having about 30 monthly users on https://aigents.com/ web site. Further work will be dedicated to increase usability, predictability and accuracy of agent behavior with greater user audience, involving more social networks and information sources.

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