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Argumentation for Collaboration Among Internet of Things

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EXTENDED ABSTRACT

Cyber-physical systems (CPS) are algorithmically controlled mechanisms involving networked devices [1]. Whereas physical components of CPS (e.g., robots sand devices) are tangible, embodied, and occupy physical space, cyber components are largely disembodied, intangible, and location-independent. As such, internet of things (IoT) are a subset of CPS. In sharp contrast to the passive view for entities of things as objects, agent inhabitants of IoT are active and may take action proactively. In this perspective, things are enlivened with agent overlays that take advantage of smart sensors and provide intended decision making capacities for things.

Numerous suggestions posit that things in physical proximity form social ties creating collaboration networks. Minimally, things provide profiles that include goods and services relevant to other things. We are focusing on interactions among people and things that lead to creation of trust, delegation, role arbitration, and thus collaboration. Nodes may perceive a level of social capital as experience prior and expected future beneficial interactions. Much needs to be developed to exploit the spectrum of sociality. We have used crowd evacuation as an illustrating case study and an exemplar for other scenarios.

In the burgeoning era of cyber physical systems, it is *essential* that embedded IoT nodes work together on matters of common interest and using *automated* argumentation reach agreements or at least commonly identify the strongest position on consequential topics. For instance, a driverless car must determine the best course of action when confronted with unavoidable collision [2]. Legal considerations as well as ethical resolutions will remain outside current proposed work. However, future explorations may bring them into our focus. We define machine to machine social argumentation *as negotiation that* include but go*es* beyond argumentation when individuals are in a socially connected network as in [3]. Settings where humans and things form collaborative teams are fascinating but remain outside our current scope. Instead, we target machine to machine argumentation as in the case of vehicle to vehicle *networks*. There have been attempts to form autonomous robotic ad hoc coalitions; e.g., [4]. Similarly, IoT nodes that monitor health status of occupants in a building must agree on the safest building location for people to congregate. This is crucial for all types of *disaster* from weather concerns to the active shooter incidents.

Argumentation is the process in which agents exchange and evaluate interacting and inevitably conflicting arguments. It is a form of dialog during which beliefs, understanding and opinions are presented, explained, compared, and defended. The arguments are the basis for inferences, negotiations, conflict resolution, and conclusions drawn by logical reasoning. Argumentation is one of the oldest research foci and one of the most enduring ones in Artificial Intelligence [5] [6] and in parallel in Philosophy, first reported in 7] and most recently in [8]. Automated Argumentation has been adapted to many domains including computational law and multi-agent negotiations [9]. The most vigorous and prolific argumentation research has been conducted with Argugrid (www.argugrid.eu), which is a grid based research consortium funded by the European Union and directed by Dr. Francesca Toni of Imperial College in London, United Kingdom. Whereas social abstract argumentation [3] facilitate online argumentation among human social media participants as can be found on Facebook, we aim to facilitate social argumentation chiefly among machines. Numerous suggestions posit that things in physical proximity form social links creating social networks. Minimally, things provide profiles that include goods and services relevant to other things [10]. For effective interaction with human peers and other animals, things need to be equipped with biological sensors (i.e., biosensors) so that their corresponding agents would ascertain conditions of their bio-organism cohabitants. For example, graphene nano-sensors are available for passive sensing of bacteria. Other typical passive biosensor exemplars are motion and vibration sensors, thermometers, audio and visual sensors, touch and tensile sensors, barometric pressure

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sensors, and a variety of chemical sensors. By fusing sensory information, a thing may determine bio-organism presence including humans at given radii from it. Agents controlling things can use biosensors as proximity sensors and behave in socially meaningful ways. Once agents inhabiting things perceive bio-presence, they may perceive and initiate as well as expect reciprocal sociality. Reciprocally, humans may perceive electro-mechanical things by sensing energy and wireless networking measures.

In the context of smart IoT devices, the first task is identification of arguments generated by their corresponding agent. Each agent is designed to receive sensory data and perform problem solving that produces an output, which might be a mere perception or an action to perform.

The problem solving module shown in Figure 1 is an expert system that encapsulates agent problem solving. Agents will fuse one or more sensory data for determining an input for reasoning. The expert system will include design and a model current applicable conditions. A periodically generated argument is a pair of sensed data and an output encapsulated as an atomic abstract argument that will be cast to compete with other arguments in the system argument pool,

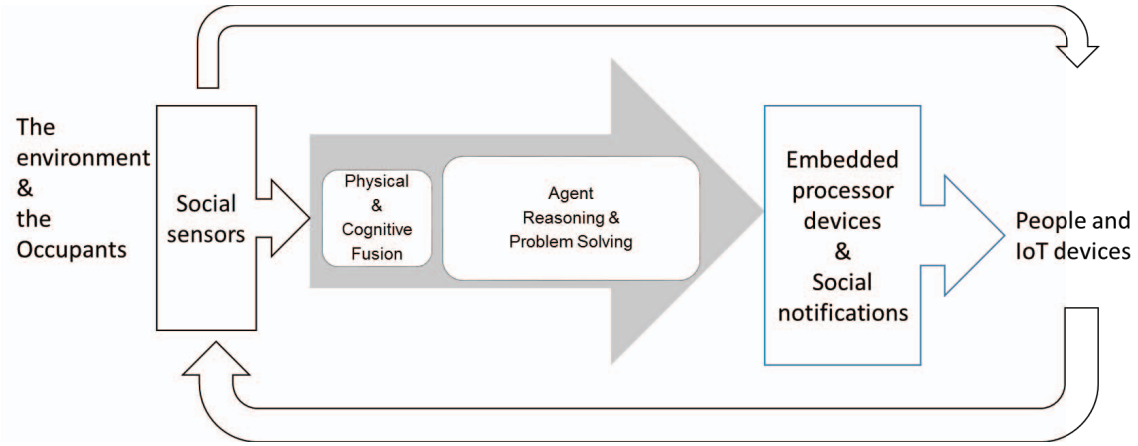

Figure 1. An agent corresponding to a smart IoT device

Keywords- Internet of Things (IoT); Cyber-physical systems (CPS); machine to machine argumentation; agent problem solving; expert system

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