A Social Inspired Broker for M2M Protocols

Vincenza Carchiolo[1][a], Alessandro Longheu[2][b], Michele Malgeri[2][c] and Giuseppe Mangioni[2][d]
[1]*Dipartimento di Matematica ed Informatica, Università degli studi di Catania, Catania, Italy*
[2]*DIEEI, Università degli studi di Catania, Catania, Italy*

Keywords: IoT, Social Networks, P2P Overlay Networks, M2M Protocols.

Abstract: Internet of things can be viewed as the shifting from a network of computers to a network of things.To support M2M communication, several protocols have been developed; many of them are endorsed by client-broker model with a publish-subscribe interaction mechanism. In this paper we introduce a multi broker solution where the network of brokers is inspired by social relationships. This allow data sharing among several IoT systems, leads to a reliable and effective query forwarding algorithm and the small world effect coming from mimic humans relations guarantees fast responses and good query recall.

1 INTRODUCTION

Internet of Things (IoT) can be considered the natural evolution of the Internet and it is expected to modify our habits in a most shocking way rather than the Internet itself. In the IoT context, several network-enabled devices provide connectivity for a set of (possibly many) objects, places and/or environments to Internet, shifting from a network of computers to a network of things (Giri et al., 2017).

While IoT represents a convergence point among different existing technologies as Radio Frequency IDentification -RFID- tags (Marquardt et al., 2010) and sensor/actuator networks (Sgroi et al., 2005, Akyildiz et al., 2002), it actually poses many challenges. In particular, to leverage smarter intelligent devices to really improve everyday life, they should interact in a fast, automatic and seamless fashion. Moreover, devices often work in a geographically distributed area subject to dynamic changes, with heterogeneity in data type, format, availability and granularity.

The resulting need for an effective Machine to machine (M2M) communication lead to several different protocols developed during last years, as CoAP, MQTT, AMQP and many others (Hunkeler et al. 2008, Vinoski 2006). Most of them are based on a client-broker model with a publish-subscribe interaction mechanism, where each client publishes messages to a broker, and brokers receive subscription requests from other clients. Every message is published to an address, known as topic. Clients can subscribe to multiple topics and receive from bokers every message published for those topics.

In this work we propose a multi broker solution for M2M protocols where each broker is a node of a social based peer-to-peer network that operates as PROSA (Carchiolo et al., 2006), (Carchiolo et al., 2008), a semantic social inspired overlay network whose query forwarding algorithm is reliable and effective and whose small world structure guarantees fast responses and good query recall.

In the proposed architecture, brokers interact not only with devices to endorse publish-subscribe mechanism for the specific M2M protocol, but also each other, providing information sharing for a distributed broker solution. Brokers communication does not depend on the actual M2M protocol being used, rather only publish-subscribe mechanism is required.

To share information among brokers, the idea we adopt is that semantic proximity of resources is mapped onto topological proximity of node, whereas

[a] https://orcid.org/0000-0002-1671-840X
[b] https://orcid.org/0000-0002-9279-3129
[c] https://orcid.org/0000-0002-9898-8808
[d] https://orcid.org/0000-0001-6910-0112

Carchiolo, V., Longheu, A., Malgeri, M. and Mangioni, G.
A Social Inspired Broker for M2M Protocols.
DOI: 10.5220/0007765101010105
In *Proceedings of the 4th International Conference on Complexity, Future Information Systems and Risk (COMPLEXIS 2019)*, pages 101-105
ISBN: 978-989-758-366-7

query forwarding/answering effectiveness and efficiency come from the social nature of PROSA network here exploited.

The paper is organized as follows. In Section 2 we consider the impact of social-based inspiration within IoT scenario, whereas in Section 3 we present our proposal in more detail, finally showing our concluding remarks and a plan for future works in Section 4.

2 SOCIAL INSPIRATION IN IoT

The influence that social-based paradigma can have in the IoT context is manifold, depending on the vision we consider. The simple "Social IoT" classification is therefore incomplete, and currenlty three types of social inspiration can be discussed, given that in IoT system is built over three concepts (thing oriented, Internet oriented and semantic oriented):

- Thing-to-Thing Social IoT (TTS-IoT)
- Thing-to-Human Social IoT (THS-IoT)
- Application-to-Application Social IoT (AAS-IoT)

Two examples of TTS-IoT are described in (Holmquist et al, 2001) and (Mendes, 2011). In the first (quite dated) work, authors exploits wireless sensor nodes to build temporary social relationships, considering how sensor owners drive the building of such relationships. In (Mendes, 2011) the idea is to provide objects with global information exchange so they become context-aware and can be involved in "conversation" like humans.

The THS-IoT approach is certainly the most natural and followed by many researchers. For instance, "Socialite" (Kim et al., 2017) is a tool that uses semantic technologies for SIoT end-user programming. In particular, authors extracted some rules from online survey, exploiting them in automatic runtime decisions in IoT scenarios. In this work, knowledge representation is semantic based and rules support information sharing to facilitate social relationships among IoT users.

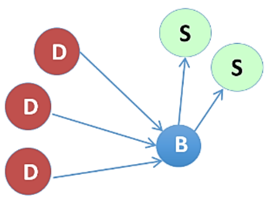

Figure 1: Publish-subscriber basic model (B=broker, D=device, S=subscriber).

Other works, as (Kranz et al., 2010) and (Guinard, 2010) highlight the integration of IoT with social networks, where social networks is used as a base for resources discovery by IoT. Even if some applications are shown (Kranz et al., 2010), these works though do not address the quiestion of building social relationship. Other approaches use cloud-based platform, as "Lysis" (Girau et al., 2017); in this work, objects act as agents with social relationships, increasing both network scalability and information discovery.

For what concerns the third approach (AAS-IoT), in (Saleema et al., 2018) a first attempt was proposed; the work promotes data exchange and reuse among IoT applications, so they can use mutual social relationships to leverage their services.

Our proposal actually can be thinked about a fourth social inspired model in IoT, i.e. the Broker-to-broker Social IoT (BBS-IoT); in other proposals, e.g. (D'Elia et al., 2018), the idea of distributed multi broker overlay platform is proposed, though no social inspiration is considered in query forwarding and answering.

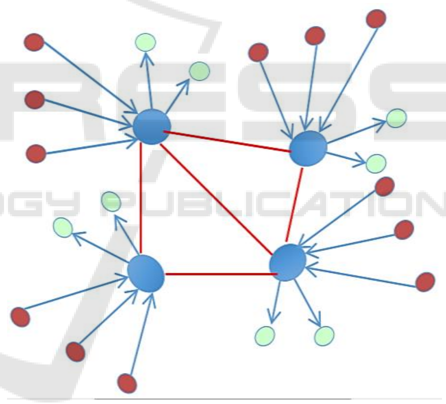

Figure 2: Multiple brokers and their IoT networks.

3 BBS-IoT WITH PROSA

Publish-subscriber protocols adopt a communication mechanism that relies on message brokers for multicast messages exchange. In particular, instead of having the sender forwarding messages to the set of receivers, the sender publish its messages (concerning a given topic) to a broker. Receivers that are interested in (and were previously subscribed for) a specific topic will receive related messages from that broker. A single IoT network can be viewed as the broker with its set of subscribers and devices (publishers), as shown in Fig. 1.

Multiple-broker approach is largely used within IoT context; each broker can share its information with others to implement a distributed broker. The general architecture is shown in Fig. 2, where multiple brokers with their IoT networks are represented.

The question is which subset of brokers should be selected to guarantee effectiveness and efficiency of the whole architecture, at the same time avoiding to spread information to brokers that are not interested in the same topic. For instance, if a broker B1 knows that B2 is the reference broker for a given topic T (nodes interested in T will subscribe to B2), a semantic link from B1 to B2 arise; whenever B1 receives a message concerning T, it sends the message not only to T's subscribers but also to B2. In general, if more brokers are involved in T, B1 forwards the message to the broker peer-to-peer (P2P) network to reach such brokers, while avoiding to spread the message to any broker.

Currently, no definitive standardization exist for this mechanism, and the overall performance in searching and retrieving resources heavily depends on the organization of broker P2P network.

The solution we propose here is to build the broker network according to the PROSA model. In particular, PROSA leverage social relatioships to exploit the small-world emerging property (Watts and Strogatz, 1998), thus resulting in efficient message forwarding.

In PROSA, two kinds of social links are considered: acquaintances and semantic link; the former models social relationships raising from interactions in everyday life (e.g. those concerning colleagues in the same office at work), whereas a semantic link models those acquaintances with which a stronger relation exists, for instance if I need IT support for my laptop, I will search not any of my colleagues, but the IT specialist. Note that a semantic–link is not symmetric.

Actually, in PROSA semantic links are split in two subcategories, i.e. temporary and full semantic links. To describe their difference, consider an example: if a friend asked us something about "golf" and we were not able to answer him, we will anyway remember that he is involved with golf. This results into a link stronger than simple acquaintances (AL), thanks to past queries, and it is called Temporary Semantic Link (TSL). Whenever an answer to a query is provided, this lead to a stronger and stronger link named Full Semantic Link (FSL).

To promote an acquaintance link to a semantic one, some additional semantic information (e.g. about interest, culture, abilities) are required. In real life semantic links building simply comes from sharing a knowledge field or a passion or simply an interest with a person and interact with him in some circumstances. Once such a semantic link is established, as soon as a need concerning that field occurs, you're ready to use that link to get assistance or collaboration. In real life semantic links are widely used to speed up information retrieval.

Our goal here is to build such a broker network, exploiting both acquaintance and semantic links; a broker joins the network to achieve links to others according to the social model described above, i.e. by linking (semantically) with broker with similar interests, culture, hobbies, works and so on, and keeping a certain number of "random" acquaintances. If the network of brokers catches the dynamics of the social model, the resulting network should be a small-world. To achieve this, we need i) a system to model knowledge, culture, interests, and ii) a network management algorithm implementing the social model.

For a given broker B1, we could assume that the set of other brokers in the broker network is viewed as a Virtual Smart Device (VSD) capable of providing information concerning various topics (Fig. 3); this way, social behaviour is encapsulated into the VSD, and this allows to not affect existing IoT networks. A better approach is tough to view the rest of broker network as a Virtual Subscriber to which B1 sends its information; this is discussed in the next paragraph.

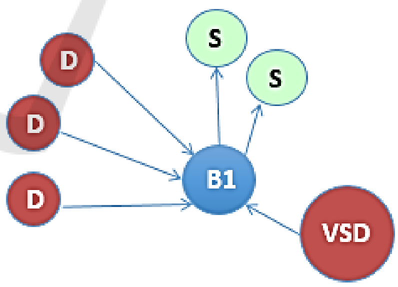

Figure 3: Modelling the broker network as a VSD.

3.1 Broker Net as Virtual Subscriber

As shown in Figure 4, the broker network is modeled as a Virtual Subscriber. In particular, a generic broker B1 behaves as a server and each one uses data variables named "Topics" and routes all the messages among connected subscriber. Topics are represented in a hierarchical form, e.g.:

```
/root/level1/../leveln/Measure
```

Where the so-called Localization is:

`/root/level1/../leveln/`

And Measure is the topic itself (named "Measure" according to typical IoT values provided by devices).

Messages are sent to all subscriber interested in the topic. Here we consider two set of subscribers:

- Local subscribers, directly connected to B1
- Remote subscribers, i.e. those reachable via the broker network

To model the attractiveness (interest) for a given topic, for Local Subscriber we exploit the MQTT standard, whereas for the Remote, hidden inside the Virtual Subscriber, the PROSA approach is adopted.

In particular, a Topic Vector (TV) is introduced, with three fields:

- Localization, that allows to identify where the topic can be extracted
- Measure, that allows to identify what topic is obtained
- Authorization, that allows to identify the level of security to be compliant with when spreading the information; this field is defined by the broker during the network joining process

The Localization is derived from the topic provided by each publisher; he/she can insert different information, as absolute, relative or descriptive spatial coordinates (examples in Table 1).

Table 1: Localization examples.

`USA/California/SanFrancisco/Silicon Valley/temp`
`myhome/groundfloor/livingroom/temp`

Absolute spatial information can be used as they are, whereas for relative information this field is turned into absolute position by fetching the position of the broker the publisher is connected to.

Finally, in the case of descriptive information, a semantic analysis is exploited to assess absolute spatial information.

In PROSA, a peer (node in the network) receiving a query forwarded by an unknown peer can extract some information about source peer knowledge from the query itself, and this can be used to establish a new link with the source peer. Whenever a broker sends a topic, in PROSA this is interpreted as a peer search request, i.e. a query to find a broker interested to that topic; in (Carchiolo et al., 2007) and (Carchiolo et al., 2010) search query management is described in detail.

During query processing, physical distance are evaluated to deal with Localization field, whereas a semantic distance (e.g. ontology based) is exploited to cope with Measure field; finally, a filtering function (ACL based) is considered to implement the Authorization field.

According to PROSA, in the broker network links building follows the way people "link" to others in social networks, i.e. relationships among people are usually based on similarities in interests, culture, hobbies, knowledge and evolve from simple acquaintance links to semantic links (TSL or FSL).

Since relationships (links) are not symmetric, it is necessary to distinguish the source broker (SB) from the destination broker (DB) in a link.

Each Broker maintains a list of known brokers, (Broker List, or BL), built on the query strategy previously described. If the link is a simple AL, the broker doesn't know the corresponding TV: in this case an empty TV is placed into the vector field. When TSL is considered, the broker doesn't know the TV of the linked Broker, but a Temporary Broker Vector (TBV) is built based on the topic information received in the past from that broker. Finally, if the link is a FSL, the TV is put in the vector field.

A new Broker that wants to join broker network, just searches other Brokers and adds some of them in his BL as ALs.

In PROSA links dynamics are strictly related to clients connected with a Broker and with the topic requested from this client. When a new client of a Broker requires information about a topic, he modify the TV of the Broker.

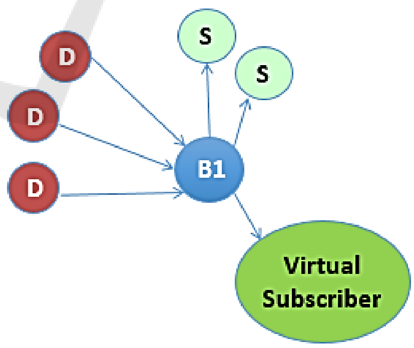

Figure 4: Modeling the broker network as a Virtual Subscriber.

4 CONCLUSIONS

In this position paper, a multi broker solution to provide support within IoT context were presented. The proposal relies on social relationships, in particular on the PROSA network whose query forwarding algorithm is effective and small world structure assure fast responses and good query recall; our proposal can be adopted to share information even with heterogenous IoT system.

Several questions though call for further investigation, in particular (1) how different brokers could share topic semantics and (2) how privacy and trust (Carchiolo et al., 2015) can be effectively managed.

ACKNOWLEDGEMENTS

This work has been supported by the Universita' degli Studi di Catania, “Piano della Ricerca 2016/2018 Linea di intervento 2”.

REFERENCES

Giri et al., 2017. Internet of things (IoT): a survey on architecture, enabling technologies, applications and challenges. In *Proc. of the 1st International Conference on Internet of Things and Machine Learning (IML '17).* ACM press.

Marquardt et al., 2010. Rethinking RFID: Awareness and Control for Interaction with RFID Systems. In *Proc. CHI 2010*. ACM Press.

Sgroi et al., 2005. A service-based universal application interface for ad hoc wireless sensor and actuator networks. In *Ambient Intelligence.* Springer Verlag.

Akyildiz et al., 2002. Wireless sensor networks: A survey. In *Computer Networks 38, 4.* Elsevier Press.

Hunkeler et al., 2008. MQTT-SA publish/subscribe protocol for wireless sensor networks. In *Proceedings of the 3rd Intl Conf. on Communication System Software and Middleware (COMSWARE'08).* IEEE Press.

Vinoski, 2006. Advanced message queuing protocol. In *IEEE Internet Computing, vol 6.* IEEE Press.

Carchiolo et al., 2008. PROSA: P2P Resource Organisation by Social Acquaintances. In *Agents and Peer-to-Peer Computing. AP2PC 2006.* LNCS, vol 4461. Springer, Berlin, Heidelberg.

Carchiolo et al., 2006. Social Behaviours in P2P Systems: An Efficient Algorithm for Resource Organisation. In *15th IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises (WETICE'06).* IEEE Press.

Holmquist et al. 2001. Smart-its friends: A technique for users to easily establish connections between smart artefacts. In *Int. Conf. on Ubiquitous Computing.* Springer Berlin Heidelberg.

Mendes, 2011. Social-driven Internet of connected objects. In *Proc. of the Interconnected Smart Objects with the Internet Workshop*. IEEE Press.

Kim et al., 2017. Empowering End Users for Social Internet of Things. In *Proc. of the Second Int. Conf. on Internet-of-Things Design and Implementation.* ACM Press.

Guinard et al., 2010. Sharing using social networks in a composable web of things. In *8th IEEE Int. Conf. on Pervasive Computing and Communications Workshops (PERCOM Workshops)*. IEEE Press.

Kranz et al., 2010. Things that twitter: social networks and the Internet of things. In *What can the Internet of Things do for the Citizen (CIoT) Workshop at 8th Int. Conf. on Pervasive Computing.*

Girau et al., 2017. Lysis: A Platform for IoT Distributed Applications over Socially Connected Objects. In *IEEE Internet of Things Journal*. IEEE Press.

Saleema et al., 2018. SCDIoT: Social Cross-Domain IoT Enabling Application-to-Appl. Communications. In *IEEE International Conference on Cloud Engineering (IC2E)*. IEEE Press.

D'Elia et al., 2018. A Multi-Broker Platform for the Internet of Things. In *Internet of Things, Smart Spaces, and Next Generation Networks and Systems*. Springer.

Watts and Strogatz, 1998. Collective dynamics of 'small-world' networks. In *Nature, 393:440–442*.

Carchiolo et al., 2007. Efficient Searching and Retrieval of Documents in PROSA. In: *Databases, Information Systems, and Peer-to-Peer Computing. DBISP2P. LNCS vol 4125.* Springer, Berlin, Heidelberg.

Carchiolo et al., 2010. An adaptive overlay network inspired by social behavior. *Journal of Parallel and Distributed Computing, Vol.70-3.* Elsevier.

Carchiolo et al., 2015. The Cost of Trust in the Dynamics of Best Attachment. *Computing and Informatics journal, vol 34.* S. Academy of Sciences Press.