Meta Social Network - Concept, empirical validation and feasibility

Paulo Matos
Research Centre in Digitalization and Intelligent Robotics (CeDRI)
Laboratório Associado para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC),
Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
Email: pmatos@ipb.pt

Pedro Filipe Oliveira
Research Centre in Digitalization and Intelligent Robotics (CeDRI)
Laboratório Associado para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC),
Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
Email: poliveira@ipb.pt

Rui Alves
Instituto Politécnico de Bragança
Campus de Santa Apolónia
Bragança, Portugal
Email: rui.alves@ipb.pt

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***Abstract*—In this paper, the authors present the concept of a meta-social network, as an abstraction layer between different social networks, capable of providing information and opportunities that the direct use of social networks does not allow. The concept is defined as an ontology that describes the relationship of the users, their entities in social networks, and the relationships they have in each of these networks, according to their semantics (friend, works, . . .). In the paper, the authors specify the ontology using Protégé and, present application examples describing their practical potential. The authors also discuss the problems and challenges that need to be resolved for its implementation.**

***Index Terms*—ontologies, social-networks, protégé**

I. Introduction

Social networks are part of everyone's life and are spread across virtually all age groups. They are used for leisure purposes, but also professionally, and it is common for us to use more than one, with some sort of segmentation by type of use. For example, Facebook is used more among friends and family; while LinkedIn is clearly associated with professional issues in the relationship between people and companies, employers and employees.

The reasons behind the success of social networks are well-known. First of all, they allow doing things in a simple and accessible way for almost everyone, which otherwise would require more technical knowledge. For example, the vast majority of users wouldn't know how to share a file with friends if it wasn't via social networks or email.

On the other hand, it combines features resulting in a higher value service. For example, it is quite common to use social networks as repositories to store photos, but also to share these photos or even allow friends and relatives to comment on them.

It is naturally a social space that, regardless of people's physical location, allows them to communicate, share, maintain interest groups, and in some way have meetings. If we think that until recently this was only possible in physical form, one can see the appeal that social networks have over all of us.

They also actively contribute to connect people, supplying advanced searching features and recommendation solutions, that identify and suggest people that might have some relationship with us: a friend of a friend, who could also be our friend; or someone who likes the same things as us. For example, reactivating friendships has become much simpler and more natural, something that would be almost unthinkable without social networks. Today, all we have to do is search or simply ask someone we know is close to the person we want to meet. And then, a simple invitation or a comment opens the way to shorten distances, not only physical but also temporal.

There are even more advanced features that the vast majority of users are unaware of and that are much closer to IT experts. For example, Facebook has a version control solution, but of course, few people use or even know what it is a version control is.

If advantages and attractions for users were easily identified, it still took some time to discover how to monetize them in terms of business. Today, their business role and function are clear: they are very effective in communication, publicity,

marketing, branding, networking, and business support, among others. With the particularity of gathering a lot of information, very valuable for certain purposes, in particular marketing and networking.

Almost all social networks request information about our age and gender. However, they contain much more information about us. Through the navigation on the social network, they know what we are looking for, what we see, and if we see it often. In addition, they also have full knowledge of our geographic context, where we live, and where we go. And, no less relevant, with whom we relate, who we follow, and what topics we like. All of this has a high economic value these days, it is no coincidence that the new large companies, such as Google and Facebook, have a large part of their business based on this information, which is sold directly or indirectly, namely for marketing purposes.

As already mentioned, it is normal for us to use more than one social network, either because our contacts are spread over several networks, or because the type of use is somehow directed towards a certain purpose. Thus, we can say that our social life in the virtual world is divided into several social networks – each one contains a bit of us, our relationships, our activities, our history, and the like.

The potential, but also the dangers, of bringing all these networks together into one can give rise to new challenges and opportunities. It is in this sense that we present in this paper the concept of meta-social network, as a solution for aggregating social networks.

This paper is structured in six sections, namely: the present with the introduction; the second section describing the state of the art; the third describes the concept and ontology defined for the purpose; the fourth section presents some application examples; the fifth section briefly addresses the technical feasibility of implementing this concept; and finally, section seven concludes.

II. State of the art

Social networks have been the motto for several areas of research, namely for opinion studies [1], opinion influence [7], [8], [15], social behavior [1], [6], recommendation solutions [10], [11], [9] or sentimental analysis [13], [12].

The quick response by the scientific community to explore social networks, results from the already existing and very well consolidated knowledge about graph theory [2], [18], [17], [16], temporal networks [3], [5], [4], social behaviors [19], [20], [14], [21], and others.

In what is the contribution of this paper, namely the concept of meta-social network, there are few publications that directly address the issue. There are, however, several papers that somehow approach social networks from an integrated or integrative perspective, namely related to User identification across social networks. In [22] the authors propose a hybrid personal information-based approach to identify users across multiple online social networks; something similar is done by [24] that proposes an algorithm to reconcile user accounts from distinct networks based on cross-linked connections; In [23] the authors present an algorithm that uses the network topology and the publicly available personal information to iteratively match profiles across n social networks; in [26] the authors propose a new method for user identity identification across social networks sites by utilizing users' overlapping relationships and corresponding social interactions among different social networks sites; in [27] the authors propose a framework that exploits the user-generated posts to match the user identity across social networks. A recommended review of this topic is supplied by [25]. All these works are focused on unifying the profiles that users may have on different social networks and not on what is possible to do with that information, that is, on the potential of the meta-social network concept.

III. Meta Social Network – Ontology

The concept of a meta-social network aims to provide an integrated perspective of the various social networks, without removing the raison d'être and individual motivation of each one.

The basic idea is to reconcile the different perspectives of users. Combining, without mixing, what can be the professional component, with the family component or even leisure or entertainment. Thus giving a unique perspective of each individual, of the totality of their relationships, their interests, and their motivations. On the other hand, establishing affinity relationships with people who do not cross the same social network, but who may have common links through other social networks.

Of course, this has dangers, namely exposing parts of our lives that are intended to be more intimate or private. However, this aggregation can safeguard certain aspects, for example, not linking the relationship between individuals and the social network in which this relationship takes place. One thing is to verify that Peter has Mary in his contact list, another very different thing is to verify that this relationship results from the social network LinkedIn or SecondLove. What we present here is not intended, at least for now, to be more than a concept explored from an academic perspective. Giving it a practical application, as explained in section V, requires the active involvement of the social networks and the individual decision of each one, to expose, in whole or in part, the identities and relationships each has in the various social networks. This should not, however, prevent us from analyzing the added value that may result from this concept. Even because in some way this complicity and this knowing too much about each one of us is already an assumed and well-known reality of the social networks we know and use. And also because, for the most part, it couldn't be otherwise, because it is from this knowledge that many of the things that we like so much on social networks result, such as getting suggestions to invite or accept someone on our network of friends. If we assume that this is the case, then we can also leave open the possibility of the concept of a meta-social network being commercially exploitable and used by anyone who is willing to give up their privacy to enjoy the benefits that may result from it.

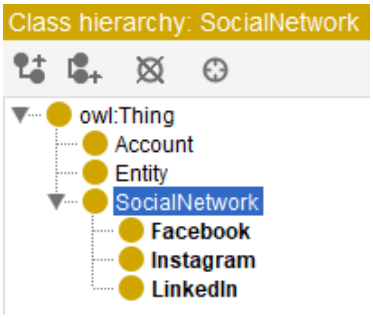

Fig. 1. Class hierarchy.

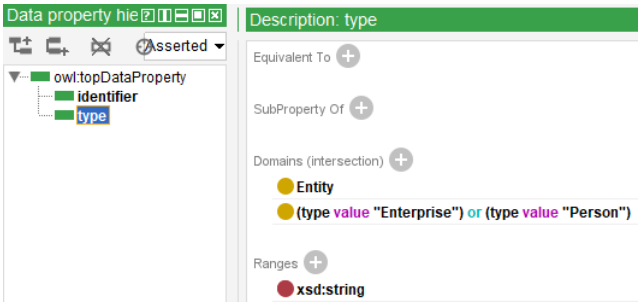

Fig. 2. Data property hierarchy.

The proposed meta-social network was defined using an ontology, creating the following concepts:

- *Entity* – Each instance represents a person or organization with presence on one or more social networks
- *SocialNetwork* – Each instance represents a social network, and there should be only one instance per network.
- *Account* – Each instance crosses an *Entity* instance with a *SocialNetwork* instance. Thus, an *Entity* that has a presence in a social network will have an *Account* instance associated with a *SocialNetwork* instance, to characterize its existence in that social network. If one *Entity* has more than one account in the same social network, each of these accounts should be represented by an instance of *Account*.

SocialNetwork has a subclass for each social network considered. As an example, the following were defined: Facebook, LinkedIn, and Instagram.

Figure 1 represents the class hierarchy drawn using Protégé [28].

In this first experimental study, we considered two data properties, namely:

- *identifier* – applies to Account instances to define the user's identifier in the social network (String).
- *type* – applies to Entity instances to define their type, only Enterprise and Person were considered for now.

Figure 2 represents the data property hierarchy. It is possible to confirm that *type* should only take the value *Person* or *Enterprise*.

Although only these two attributes are defined, it is clear that others will be needed for a better characterization of *Entity*, *Account*, and *SocialNetwork* instances.

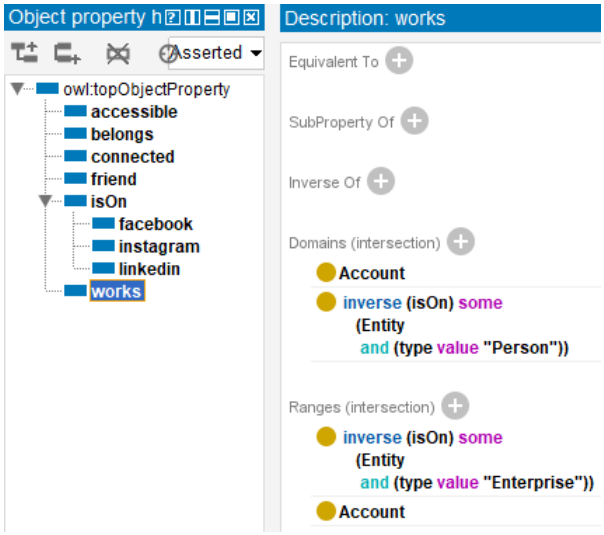

Fig. 3. Object property hierarchy.

Four object properties were defined, namely:

- *isOn* – relates an *Entity* instance to an *Account* instance and signals that a given entity has a presence in the *SocialNetwork* associated with the *Account*. It is a super property of::
  - *facebook* – In this case, the *Account* instance is associated with the *Facebook* instance.
  - *linkedin* - In this case, the *Account* instance is associated with the *Linkedin* instance.
  - *instagram* - In this case, the *Account* instance is associated with the *Instagram* instance.
- *belongs* – relates an *Account* instance to the *SocialNetwork* instance.
- *friend* – relates two *Account* instances, whose type is *Person*, between which there is a friendship relationship of the respective *Entity*'s.
- *work* – relates two instances of *Account*, the first whose type is *Person* and the second whose type is *Enterprise*, between which there is a professional collaboration relationship of the respective *Entity*'s.

Figure 3 represents the object property hierarchy. Here it is possible to see that the *works* property was defined in the sense that the *Account* of the domain is related, in the opposite sense of the *isOn* property, with an instance of *Entity* with the property *type* set to *Person*; and the *Account* of the related range, in the inverse sense of the *isOn* property, with an instance of *Entity* with the property *type* set to *Enterprise*. Something similar was done for the *friend* property, but here the *type* is set to *Person* for both domain and range.

The *friend* property is transitive and symmetric, that is, if A affects B and B affects C, so A affects C (reflective); and if A affects B then B affects A (symmetric).

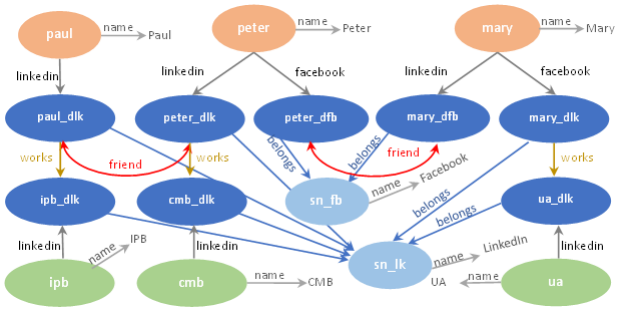

Fig. 4. Full ontology representation.

IV. Application Examples

In this section, some possible uses of the previously defined specification are presented. For each example, attributes appropriate to the situation and some inference rules were defined, using the Semantic Web Rule Language (SWRL) [29].

A case study was defined involving three *Entity*'s of *type Person*: *paul*, *peter* and *mary*, each one associated (through the *works* property) to an *Entity* of *type Enterprise*, respectively, *ipb*, *cmb* and *ua*. There are also two *friend* relationships, one between *paul* and *peter* via *LinkedIn*, and another between *peter* and *mary* via *Facebook*. Figure 4 represents all the created instances and part of the relations. In salmon color are represented *Entity* instances of *type Person*; in green *Entity* instances of type *Enterprise*; in dark blue the instances of *Account*, in which the suffix *_dfb* is used for instances associated (*belongs*) to the representative instance of *Facebook* (*sn_fb*); and the suffix *_dlk* is used for instances associated with the representative instance of *LinkedIn* (*sn_lk*). The data property *name* is also represented for the instances of *Entity*. And in light blue the instances of social networks (*Facebook* and *LinkedIn*).

A. Measure the influence of an Entity

Measuring the influence of a particular person or organization within a social network is common and is done in current networks. However, the meta-social network concept allows a much broader perspective allowing to obtain more realistic results. For this purpose, two new properties were defined, *connected* and *accessible*. The *connected* property applies between two *Account*'s and it will result as true if they are related to each other through the *friend* property, that is, if there is a *friend* relationship between them or if there is a *friend* relationship between the *Account* of the domain and a third party *Account*, such that the latter is *connected* with the *Account* of the range. The definition of *connected* in SWRL results in:

$$\text{friend}(?p,?q) \rightarrow \text{connected}(?p,?q)$$
$$\text{friend}(?p,?x) \wedge \text{connected}(?x,?q) \rightarrow \text{connected}(?p,?q)$$

The second property, *accessible*, makes use of *connected* to check if there is a chain of relationships, via the *friend* property, between two *Entity*'s of type *Person*. Its definition in SWRL resulted in the following:

$$\text{isOn}(?p,?si) \wedge \text{connected}(?si,?sf) \wedge \text{isOn}(?q,?sf) \rightarrow \text{accessible}(?p,?q)$$
$$\text{isOn}(?p,?si) \wedge \text{connected}(?si,?sx) \wedge \text{isOn}(?t,?sx) \wedge \text{accessible}(?t,?q) \rightarrow \text{accessible}(?p,?q)$$

Both properties, *connected* and *accessible*, are transitive and symmetric.

Thus, through the *accessible* it is possible to determine all the *Entity*'s to which it is somehow related by the *friend* property. The SPARQL query in Figure 5 illustrates how this value is calculated for the instance of *Entity* with the *name Paul*. It is necessary to take into account that because the *friend* property is symmetric, the instance itself is considered in the quantification.

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX sn: <http://www.semanticweb.org/pmato/ontologies/2023/5/metaSocialNetwork#>

SELECT DISTINCT ?name (count(distinct ?subject) as ?Count)
WHERE {
        ?p sn:name ?name ;
        sn:accessible ?subject .
        FILTER(?name = "Paul")
}GROUP BY ?name
```

?name	?Count
Paul^^xsd:string	4

Fig. 5. Query to account for the influence of an entity.

B. Marketing from one context via another context

This second example explores situations where there is an *Entity*, for example, an influencer capable of accessing a relevant target, but on a social network that is not the most suitable for the kind of marketing that is supposed to be done. A concrete example is: the influencer has access to the target market on a professional social network and the product to be advertised is of personal or family nature.

Applied to the case study, we can consider *paul* as the influencer and the *Facebook* target social network. The ideal would be to describe a triple that relates the Entity that matches the influencer, the social network where the target of the marketing campaign is, and the Entity that is part of this target. However, in RDF/OWL, properties are constrained to two parameters. The idealized solution was to consider the social network in the property itself, creating two new properties for this purpose, *connected_fb* and *accessible_fb*, in this case, applicable exclusively to *Facebook*. It will be necessary to define the same pair of properties for each of the considered networks.

The *connected_fb* is similar to the *connected* property, but constraining the object to belong to the *Facebook* social network. The second definition of *connected_fb* allows to reach *friends* of *friends* that are also on *Facebook*.

$$\text{friend}(?p,?q) \wedge \text{belongs}(?q,?sn) \wedge \text{name}(?sn,\text{"Facebook"})$$

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX sn: <http://www.semanticweb.org/pmato/ontologies/2023/5/metaSocialNetwork#>

SELECT ?subject
WHERE {
        ?pp sn:accessible_fb ?subject .
        ?pp sn:name "Paul"
}
```

?subject
sn:mary
sn:peter

Fig. 6. Query to identify *Entities* from the *Facebook* social network achievable throw the *friend* property.

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX sn: <http://www.semanticweb.org/pmato/ontologies/2023/5/metaSocialNetwork#>

SELECT DISTINCT ?person
WHERE {
        ?paul sn:accessible ?person .
        ?person sn:isOn ?person_social_network.
        ?person_social_network sn:works ?enterprise_social_network.
        ?enterprise sn:isOn ?enterprise_social_network.
        ?enterprise sn:name "UA".
}
```

?person
sn:mary

Fig. 7. Query to get contact in a certain enterprise/institution.

$\rightarrow$ connected_fb(?p,?q)

friend(?p,?x) $\wedge$ connected_fb(?x,?q) $\rightarrow$ connected_fb(?p, ?q)

connected_fb, however, does not allow connecting Facebook communities that are interconnected by *friend*-type relationships only in other networks. For this purpose, the *accessible_fb* property was defined. The first definition allows us to check the connection directly among *Entities*. The second definition, which is recursive, allows the existence of a *friend* type relationship, in any social network with a third *Entity*, in which the latter satisfies the *accessible_fb* relationship with the final *Entity*.

isOn(?p,?si) $\wedge$ connected_fb(?si,?sf) $\wedge$ isOn(?q,?sf) $\rightarrow$ accessible_fb(?p,?q)

isOn(?p,?si) $\wedge$ friend(?si,?sx) $\wedge$ isOn(?t,?sx) $\wedge$ accessible_fb(?t,?q) $\rightarrow$ accessible_fb(?p,?q)

Using the *accessible_fb*, it is now possible to compute the entities belonging to the *Facebook* social network, achievable through the *friend* relationship. The SPARQL query in Figure 6 shows how this value is calculated for the instance of *Entity* with the *name Paul*.

C. Get contact in a certain enterprise/institution

Social networking is a fundamental component of professional success. Finding out who among our acquaintances can put us in contact with a certain company, or department can be the difference between total failure and success. Social networking is used to get job and business opportunities.

The use of social networks for networking purposes is already a common practice, but the use of the meta-social network can produce results that are not possible using a single social network. A plausible scenario is having a friend on our private social network who, through their professional social network, knows someone in the company we want to contact.

In this case, the solution is achieved based on a SPARQL query and based on the *accessible* property implemented for the first case study - Figure 7. The *accessible* property is used to get an *Entity* of *type Person*. If this such *Entity* is associated with the target enterprise/institution by the property *works*, applied among two social networks instances, one of the person related with the enterprise and the other one related with the self enterprise, then that person will be our contact.

V. Technical Viability

We believe that the exercise carried out with the case studies presented here demonstrates the potential of the meta-social network concept. But as already mentioned, if there are advantages, there are also disadvantages, or at least situations that need some care, because there will be a greater knowledge of users and their relationships, in the various social aspects that each of us has (private life, professional, ...). Any of the examples presented could be used to obtain information considered as compromising.

However, this danger needs to be better characterized. If the distance between those involved, measured in terms of the number of *friend* type relationships, is large (we would say greater than two), it is difficult to draw any kind of elation about the relationship between those involved. It becomes compromising if the relationship between those involved is direct, even using different social networks. One way around this would be to limit access to the ontology, i.e. native properties such as *friend* and *work* should not be directly usable. The service to be provided should be based on concepts such as *connected* and *accessible*, because they say nothing about whether the relationship between those involved is direct or not. But in practical terms, this would prevent us from having useful answers, as the aim is not so much to know if is possible to reach a certain target, enterprise, or person, but to know how to get there, that is, which contact after contact would be necessary to reach the target.

This brings us to the bottom line about the technical viability of the meta-social network. The danger of exposure described above is very well identified by the social networks, with strong social and civil responsibility. There are several known cases of exposure of private data and the impact this had on the reputation of these social networks. Sometimes even with considerable fines by the supervisory authorities.

In practical terms, social networks simply prevent access to the basic information that would support the creation of ontology instances. This would only be possible, in technical and legal terms, if each of the Entities is authorized to share their data (contacts).

From another perspective, which is somehow supported by the existing relationship between people and social networks, in which we adhere to social networks because we understand that the benefits outweigh the disadvantages and dangers, the

same can be applied to the concept of goal-social networks. It would be enough for this, that in the current social networks, there was the possibility of choosing to share, in part or in whole, the information. This would safeguard relationships that we understand should not be shared at all, and those that we somehow see advantages in sharing would be available.

VI. Conclusion

This is an experimental work that has no immediate goals for practical application. The objective of the article was to present, formalize, and discuss the concept of a meta-social network, describing some of the advantages and disadvantages already identified, as well as restrictions and constraints identified for its implementation.

We present the concept, implement the ontology that supports it as a prototype, purposefully reduce it to the essentials, and use it to demonstrate the technical viability of the concept and support the case studies. These were designed to show the potential of the concept.

The idea itself is not entirely innovative, companies like Meta to which Facebook, Instagram and WhatsApp belong, have already been working on the concept to integrate their own social networks. They do not approach integration in a transversal way, as probably due to strategic and commercial interests, they are not interested in involving other players. However, we believe that the advantages of the concept result, not only, but in large part, from the diversity of the target audience and the purpose of the social networks involved.

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