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Seamlessly Mediation of Social Interaction Services Respecting Communication Preferences †

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Abstract: The diversification and evolution of social media tools conveys users to adopt new systems and use new features of existing ones. Although this dynamism is suitably addressed by digital natives, it usually limits the technology adoption capability of digital immigrants, e.g., older adults, who react more slowly and with less confidence to the introduction of new computing systems. In order to support digital immigrants to deal with such a challenge, this paper proposes a ubiquitous system that mediates the communication supported by client applications and regular social interaction media such as, Gmail, WhatsApp, and Telegram. The system, named Social Message Translator, translates social media messages in both directions and self-adapts the process according to the behavior of end-users. Thus, it deals with the digital diversification of the former and also with the changes in the social media preferences of end-users. Consequently, digital immigrants are able to perceive as useful the supporting technology for longer time spans. The correctness of the message translation system was evaluated using a laboratory case study. The obtained results were highly positive, opening several opportunities to use this translator in several social interaction scenarios.

Keywords: ubiquitous social interaction; social media evolution; asymmetry of social media preferences; digital immigrants

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1. Introduction

According to Shannon's theory of communication [1], a transmitter sends a message to a receiver through an interaction channel. If any of these factors fails, the communication process cannot be completed. Therefore, if two parties (e.g., two family members) do not interact using the same communication channel, then their interaction becomes unfeasible, at least in a direct way.

In the case of current means for supporting computer-mediated communication, each interaction channel is represented by a particular social media application, such as Facebook, WhatsApp, Telegram, Skype, or ad-hoc systems. Besides email applications, modern social media interaction tools do not adhere to standard protocols that allow them to interoperate at both service and data level. Therefore, every system evolves following its own path, looking at the future more than at the present and past. In consequence, modern services only keep compatibility with their latest versions.

The frequency of evolution in these applications is usually high [2], so it causes an asymmetry of social media preferences between digital natives and immigrants. This situation negatively affects the latter and is a cause of potential social isolation. Recent literature shows that this asymmetry is still an open research problem and spans over several factors, such as age, culture, life routines, and technology appropriation level of the participants. By conducting an initial exploratory interview study with a representative sample of the target population, we corroborate that this asymmetry of media preferences exists.

In order to reduce this asymmetry and therefore allow extending the perceived usefulness in time of the social media tools adopted by digital immigrants, this article proposes the design of an intermediary software system that ubiquitously translates messages between both sides of the communication channel when required. The system, named Social Message Translator (SMT), deals with both sources of interaction asymmetries; i.e., systems evolution and changes in the social media preferences of digital natives. Thus, a digital immigrant could keep using a particular user interface and interaction paradigm over the time, regardless of the evolution of the regular social interaction systems preferred by other members of his/her social network (e.g., family and close friends).

The correctness of the designed message translation mechanisms implemented in SMT was evaluated in a laboratory case study. The obtained results show these mechanisms allow commercial or ad-hoc social applications to interact in an easy and transparent way, if certain requirements are met by the involved systems. In that respect, the capability of SMT to reduce this asymmetry aligning communication channels was evaluated involving dyads of users composed by one digital immigrant and a related digital native. The results indicate that all messages were correctly delivered to the right channel in the right format, thus allowing the alignment of the interaction channels. Therefore, it turns feasible to reduce the underlying asymmetries of interaction media preferences. These results open several opportunities to improve the interoperability among social interaction systems.

Next section reviews related work. Section 3 briefly presents the results of an exploratory interview study conducted with a representative sample of the study population, in order to assess whether the stated asymmetry is present in the study domain. Section 4 introduces the interaction scenario that is being addressed. Section 5 describes the proposed system and its main components. Section 6 explains the evaluation scenarios and discusses the experimental results. Section 7 presents the conclusions and provides perspectives on future work.

2. Related Work

We may initially think that the issues of mediating intergenerational interaction through the use of technology would be solved when current "digital natives" (i.e., younger generations) reach the older age. However, our own ability to adopt new technologies falls behind their rapid evolution [3]. Consequently, aligning asymmetries due to media preferences can be envisioned as a relevant problem in the future, while the means to deal with it may be different to the current technology.

Designing systems able to interoperate (at message level) with several communication services, needs to count on correct software interfaces to mediate the interaction. To the best of our knowledge, there are currently no specific guidelines for designing and deploying such systems in the particular case of intergenerational encounters; therefore, this problem still remains open.

A first—basic—requirement that these systems need to comply with, is the ability to intercommunicate different media services. In that respect, a mandatory restriction to increase user experience, and therefore increase the odds of user acceptance and appropriation, is that such services are perceived as "transparent" by end users. For instance, the former can automatically connect the interested parties while the latter do not need to initiate sessions across several applications in order to sustain the interaction. In particular, older adults must be able to use a unique interface to communicate with their desired parties.

In order to enable the communication between these services, it turns out necessary that the interaction channels are based around public interfaces that enable the connection through Internet. This is usually achieved through Web APIs (Application Programming Interfaces) that allow sending and receiving messages following a client-server architectural pattern.

Unfortunately, there are two major issues that need to be addressed for reaching a practical solution. On the one hand, despite the strong similarity between the different social media channels currently offered to the large public, none of them uses a standard protocol for exchanging messages. The exceptions to this situation are email and IP phoning, which in turn do follow clear and widely used protocols. On the other hand, despite the large amount of third-party applications broadly available to interact through social networking services, most service providers offer limited or no public APIs to their services. For instance, WhatsApp does not allow third-party applications to access contacts or enable interaction between them [4], even menacing users to block them indefinitely from using the service. Other services, like Facebook, allow third-party applications to access their services through a public API, but behind a pay wall [5]. Finally, there are other services like Skype [6] and Telegram [7] that allow third-party applications to access their services for free, where the communication protocols are public and open. All of these restrictions impose that software designers might need to find their ways only with social media services exposing public and open APIs, given that other applications may be unreachable in one way or another to third parties.

Finally, there are standard communication protocols that allow users to interact with all of the functionality offered by current social media services (such as sending text messages, audio, images, and initiating phone calls). However, they are not widely used in practice as a way to mediate the interaction through third-party applications. In particular, the XMPP protocol—developed by the XMPP Standards Foundation (XFS) [8]—effectively enables computer-mediated communication. However, it was in the end dropped by most service providers due to the pursuit of higher market shares. For instance, WhatsApp currently uses a variant of XMPP, which was modified to reduce the size of communication packages, and therefore increase stability and system performance.

For all of the reasons above, there are currently no standard solutions to actively engage multiple users—interacting with different social media providers—in a simple and transparent way. Given the particularity of the study scenario, i.e., intergenerational interaction to and from older adults, both usability and perceived usefulness appear as mandatory requirements, which should be addressed by any kind of proposal aiming to be deployed—and accepted—in the wild. For the sake of simplicity, we have limited the scope of the addressed problem to asynchronous communication, as a proof of concept to evaluate user acceptance of this interaction paradigm. This reduces the technical effort required to deploy more complex means of communication, which can be supported through Skype using their public and open API. Next section summarizes the results of a study that corroborate this asymmetry of interaction tool preference is present in the application domain addressed in this paper.

3. Exploratory Interview Study

Trying to understand the current extent of communication asymmetries in intergenerational exchanges, we ran an exploratory interview study. To do so, we conducted a semi-structured interview with a sample of 23 participants (adult children and grandchildren), who self-declared to engage in regular interaction with at least one older adult in their families.

3.1. Empirical Design

By snowball and convenience sampling, we reached to 23 participants, who communicate at least once a week with an older adult in their families. The study sample was approximately balanced in terms of gender (12 female, 11 male) and generation (11 adults, 12 young adults/teenagers). The three authors of this paper conducted in-person semi-structured interviews at the participants′ homes or at place of their convenience, as requested by some interviewees. All participants were asked to provide their free, explicit, and informed consent before starting the interviews. In the case of underaged participants, they provided assent to participate in the study and formal consent was obtained from their legal tutors (one of their parents in each case). No interviewees declined participation nor asked to withdraw their answers after ending the interviews.

Interviews lasted for about 20 min (M = 19.8, SD = 2.3) and covered the following themes: (1) preferred communication media to contact the older adult during leisure time; (2) preferred communication media to contact the older adult when busy at work; (3) influence of perceived importance when initiating the interaction (e.g., an important or critical message, as opposed to informal chatting); (4) influence on answer delays (e.g., approximately synchronous or asynchronous interaction); and (5) perceived usefulness of counting with computer-supported services to mediate the interaction between the participant and the older adult in his/her family. Before conducting the study, all interviewers agreed on the script and study protocol during a technical meeting for planning the intervention. Wording issues in the interview prompts and potential ambiguity in the obtained answers were controlled through a small-scale pilot study, which was run before reaching to the selected interviewees.

In order to analyze the collected data, summary statistics were calculated for close questions (e.g., what tool would you use for sending an important message to your older adult during work hours?). For open questions (e.g., how useful would you consider a seamless software service that lets you use your preferred communication media in this particular situation?) we followed an approach inspired by the grounded theory approach. In that case, we performed open, selective, and axial coding for later identifying emerging themes in an affinity diagram.

Interviews were conducted independently by the three authors until reaching data saturation. Analysis was performed individually by the third author, and later discussed jointly with the research team in order to mitigate potential observer bias. Initial results were triangulated with the findings obtained in a prior study conducted by two of the paper authors [9].

3.2. Results and Discussion

When asked for the preferred means to initiate informal social interaction during leisure time (e.g., chatting or greeting the other party), a large majority of participants across both generations declare interest in using mobile instant messaging services (89%), particularly WhatsApp. This is not surprising, given that most of these participants use extensively their smartphones, particularly WhatsApp or Telegram, for communicating with other members of their own social networks (mainly other relatives and friends). Following the same line of reasoning, when the social availability turns to be more complicated (e.g., when trying to convey an important message while busy at work), instant messaging still remains the preferred communication channel among younger generations (73%). However, in this case, adults declare a larger variety of answers, including phone calls (35%) or email (19%). It is important to note, though, that these answers correspond to the preferred communication channel by each party, not necessarily the tool they use for actually interacting with their older adults.

When queried about the perceived usefulness of a potential service to mediate the interaction between the participants and their older adults (like the one designed and reported in this paper), most participants are largely favorable. Along with the reasons stated to justify their choices, participants expressed interest in that such a service would need to be able to accurately transmit the outgoing message. That way, it would provide older adults (or digital immigrants more in general) the ways for maintaining the interaction seamlessly. Likewise, interviewees praise the possibility of using their tools of preference in a way that allows them to switch outgoing services according to the social situation in which they currently are during the day. For instance, being able to select the outgoing media while at work (e.g., email or phone) as opposed to instant messaging (e.g., Telegram) or social networking services (e.g., Facebook) while at home during their spare time, without needing to switch from one application to another.

In summary, in the studied particular context, and considering the interoperability limitations of the interaction tool (at least in terms of message exchange capabilities), it becomes evident the need to develop a software component able to that acts as a communication hub grouping different social media services. This tool should enable asynchronous interaction in a transparent way, as well as being able to effectively use third-party social computing systems (e.g., domestic tools to support and facilitate intergenerational interaction involving older adults, such as SocialConnector [10]). Considering these design inspirations, the proposed SMT system was intended to address such challenges.

4. Social Interaction Scenario

As mentioned before, SMT acts as intermediary between client applications and regular asynchronous social interaction systems, like Gmail, Telegram, and Skype message channel (Figure 1).

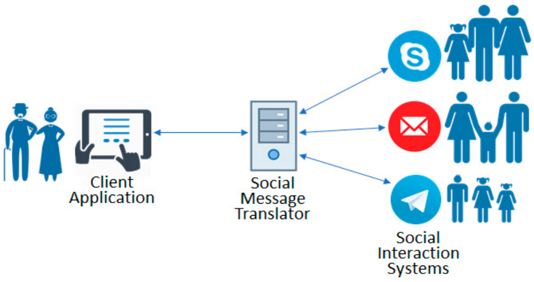

Figure 1. Architecture of the Interaction Scenario.

The three types of applications (i.e., Skype, Gmail, and Telegram) run autonomously and interact between them through the Internet when a social message exchange is required. The message exchange supported by SMT is full-duplex, even if the applications used by the transmitter and receiver are not the same. This message translator implements an API that allows client applications (e.g., commercial or ad-hoc tools) to exchange messages with regular social interaction systems when the latter are supported. Such a support is implemented through specific "translators" that must be developed for each social system. These translators are software components that ensure the maintainability of SMT and its capability to keep up with the pace of the evolution and diversification of these. Therefore, adding the support for a new social interaction system, or an evolution of an existing one, only requires the implementation of a new translator for such an interaction source, and later appending it to the SMT system.

This way to decouple the interaction support for each social system allows SMT to add and remove translators on demand. Provided that every new implementation or adjustment of a translator represents an encapsulated development, the effort and risks involved in that activity are bounded. Moreover, a failure in that activity does not jeopardize the rest of the services offered by the SMT system.

5. The Social Message Translator System

The structure of the SMT system involves two main components: a Web API and the system logic (Figure 2). The first one includes several endpoints that allow client applications to exchange asynchronous messages with social interaction systems. The second component is mainly focused on keeping the coordination of interactions between the involved parties in a conversation, and also translating messages in both directions through a secure environment. Client applications can interact with the translator by using its API, while this latter component interacts with social interaction systems using the API they implement. Therefore, new social systems can be supported whenever these systems implement a public API that allows authenticating users and exchanging messages.

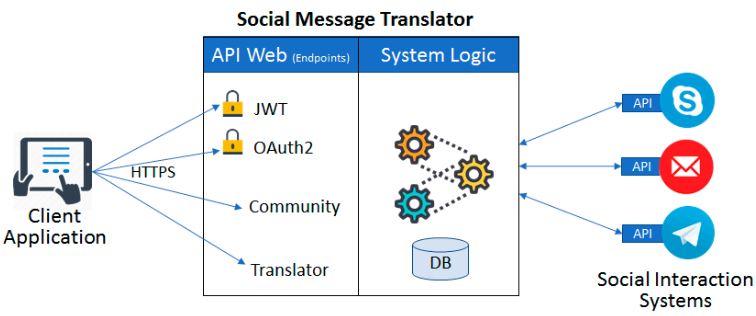

Figure 2. Structure of the Social Message Translator

5.1. System API

Client applications use several HTTP methods (e.g., GET, POST, etc.), available through different URLs, to access the services provided by the Web API. Although this API is public, the access to its services requires that the user (that accesses through a client application) authenticates utilizing any social interaction system due to security reasons. This authentication process supports both JSON Web Token (JWT) and the OAuth2 standard. Its main goal is to verify the credentials of a user to access a certain account in a social interaction system. Such a validation process is performed between SMT and the API of the corresponding system. The negotiation between them is based on token authentications. Therefore, this process is transparent to end-users. This avoids that people have to periodically enter usernames and passwords to exchange messages with other members of their social networks (e.g., friends or family).

The services provided by the Web API were grouped in three categories according to the concerns they address: authentication, community support (directory of contacts), and message translation. This design was conceived as a general solution, where its components are reusable and adaptable according to the interaction needs. In the following subsection we describe the three categories of end-points.

5.1.1. Endpoints for Authentication

Both protocols supported in the Web API (i.e., JWT and OAuth2) require that the end-user authenticates into a supported social system. The use of login and password is required just once, when the client application runs for the first time. After that, the social interaction system used in the authentication returns an access token to the client application, which will be used by the latter to demonstrate the user identity during the next interactions. This access token is a renewable unique code linked to that user. It represents the authorization of a specific social interaction system that allows a client application to access data stored in the user's account. This access is done through the API implemented by the social system. Thus, the client application and SMT can make API requests to the social systems on behalf of the user.

Access tokens are kept confidential in transit and in storage, and they are visible only to the client application and social interaction system. In other words, the tokens are never stored in the translator. Every time the translator needs to interact with a social interaction system, the former has to ask for a valid access token to the client application. Such an application should ensure that the storage of the access token is not accessible to other applications on the same device. In the case of SMT, the system uses the regular security mechanisms provided by Android 6 and upper versions. For security reasons, access tokens are used only over an https connection, since passing them over a non-encrypted channel is easy to intercept for third parties.

5.1.2. Endpoints for Community Support

Every client application that uses the services of SMT should provide to this latter component the minimum information to interact with the social interaction services. This information is the *social actor description* and its *directory of contacts* (Figure 3). The actor description identifies an end-user in the SMT system and also in all social interaction systems that will be potentially used by such a person during the message exchange. Therefore, the social actor should have a user account in every social system through which he/she wants to interact with others. Such information, and also a prioritized list of social systems preferences, is part of the social actor description.

The directory of contacts is optional and is typically used as a filter that allows identifying spam messages or contacts from people outside the social actor's community. The designer of the client application should decide if SMT must block these interaction requests or allow the social actors to decide about it. The directory also has, for each contact, a prioritized list of systems preferences. It helps identify the most suitable social interaction system through which a message can be sent, depending on several interaction conditions; e.g., if it is a new message, a regular reply or a late answer.

Considering all these considerations, we will refer to users of client applications as "social actors" (that usually correspond to digital immigrants), and regular users of social interaction systems as "social media users" (that usually are digital natives).

```
SocialActor:: { App_Id, SMT_Id,
{SocialSystem, Username}*,
{SystemPreference}*,
Contacts
}

Contacts:: {App_Id, SMT_Id,
{SocialSystem, Username}*,
{SystemPreference}*
}
```

Figure 3. Conceptual structure of a Social Actor.

5.1.3. Endpoints for Message Translation

These endpoints allow a social actor logged in a client application, and authenticated through a social interaction system, to exchange messages with social media users. These actors do not necessarily have a community (i.e., a list of contacts) recorded in the SMT system. Using the endpoint `/community/check/messages` the API allows a social actor to check if new messages have been received from their accounts recorded in the SMT system. In order to get an answer, the social actor must be authenticated. In this case, a JSON file with the following format is returned:

{"news": boolean, "count": integer}

where "news" indicates if new massages are available (true/false), and "count" indicates the number of new messages (zero messages by default). Then, the client application decides when to retrieve the messages using the endpoint: `/community/getMessages`. A more detailed description of the system and the API is available online [11].

5.2. Social Message Translators

Given that SMT must deal with the evolution of the social interaction systems and user preferences, it should be easy to add or adjust message translators to the system. Therefore, SMT implements a translator factory that is in charge of identifying the appropriate translator according to the user preference or the requirements to provide the translation service. Figure 4 shows the class structure, indicating that all translators implement the same interface. Thus, all translators will have the same structure, changing only the way in which they translate the message. This not only allows encapsulating the logic of each translator, but also establishing a pattern to implement new ones.

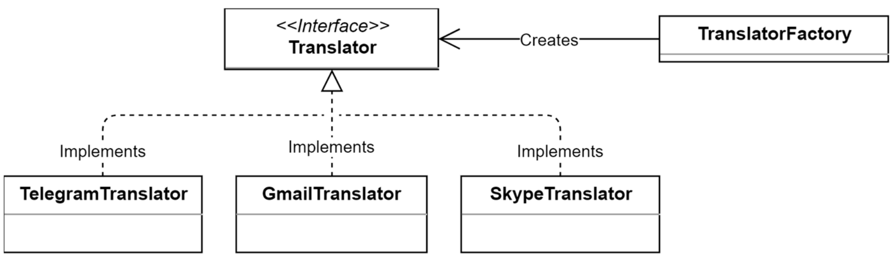

Figure 4. UML class diagram of the translator factory.

All operations are performed on a message object that includes, for instance, transmitter, receiver, and social interaction system through which the message will be sent. These objects are stored in the database used by the translator, which has the structure shown in Figure 5. This data model shows the support for communities, community members (social actors), social networks (social interaction systems), systems preferences, and social network membership. Moreover, this information space records the messages that a user exchange through a particular interaction system, and it also implements an interaction log for the whole platform.

Once a message stored in the database is successfully delivered to the destination, its content is deleted due to privacy reasons, keeping only the trace of the message. Then, this trace is used to determine if the user preference has changed in the last time; e.g., in the last month.

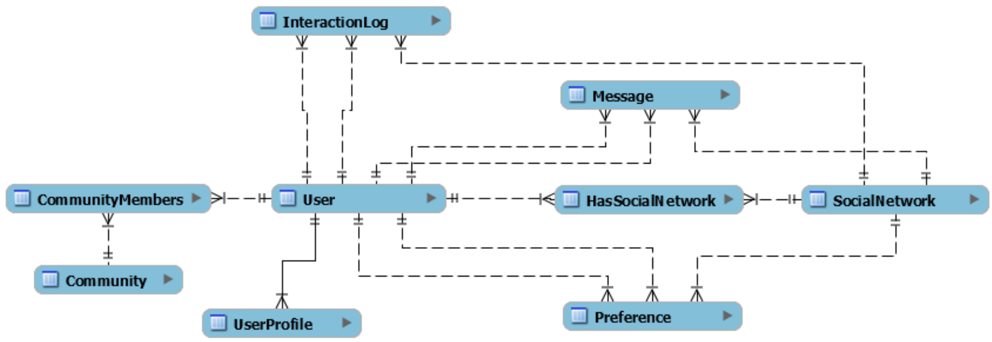

Figure 5. Data model of the SMT system.

5.3. User Preferences

Identifying the appropriate interaction system (or social channel) through which a message should be sent to a social media user is highly relevant, since only if both users share the same channel the communication process will be effective. Determining the suitability of an interaction system requires more than identifying the social media tool preferred by a user. As shown in Figure 5, in the SMT system this preference is represented by a tuple that includes the transmitter, the interaction system and the receiver. This means that a social actor (digital immigrant) will have a preferred social interaction system to contact each particular social media user (digital native), and vice versa.

Such a user media preference is automatically calculated by SMT, based on the users´ behavior. Therefore, if their behavior changes, their preference will be adjusted accordingly. In order to identify changes or the need of adjusting the user preference, the translator uses the message traces of each pair of users during the last month. Otherwise, it considers the last 10 messages if there is few or no communication records between them. Based on such information, the system uses the Holt-Winters model with tendency and seasonality [12], to forecast the most appropriate system to deliver a message to an end-user. Once the conversation is established, the SMT system will deliver the response to a message through the same channel used by the transmitter in the previous iteration. This creates the perception in the users that they are using the same interaction system, although they are really using different tools. This perception of ubiquitous interaction among users is maintained by the SMT system and it is invisible to the end-users.

6. Empirical Evaluation of the Mechanisms for Translating Messages

The SMT system was evaluated through a simulated case study that involved 30 different technical scenarios, where the SocialConnector system [10] was used as client application, and Gmail, Skype messages, and Telegram were used as social interaction systems. Three social media users (digital natives) and one social actor (digital immigrant) were represented in the tests; all of them had different social interaction system preferences. Next we describe the experimental settings, the observed variables, the obtained results, and a discussion in light of these results.

6.1. Settings of the Experiment

All messages were mediated by the SMT system and they involved one digital native (User 1 to User 3) and the digital immigrant (User 4). Users U1 to U3 belong to the family community of U4 and therefore they are in the contact list of U4. The social media preference of U1 to interact with U4 is the following (ordered from higher to lower): Skype, Gmail and Telegram. Similarly, the ordered preferences for U2 are Gmail, Telegram and Skype; and for U3 are Telegram, Skype and Gmail.

The conversations started alternatively from the social actor side (U4) and from the social media user side (U1 to U3). Some responses to each received message were delivered before 24 h from received the last message, and others after such a deadline as a way to identify if the users′ preferences were properly considered by the SMT system.

The message exchange involved text messages, text messages with an attached picture (500 kB), and also with an attached video (5 MB). The observed variables were: (1) the correctness of the resulting messages, (2) the time elapsed to reach the destination, and (3) the suitability of the channel selected to deliver each message.

6.2. Experimental Results

Table 1 summarizes the results obtained in the evaluation scenarios. The first column identifies the scenario being considered. Columns 2 to 4 indicate the message transmitter, the channel used to deliver the message, and also if such a message corresponds to an answer to a previous message. Columns 5 and 6 indicate the message receiver and the channel used for that reception. Columns 7 to 9 indicate the time (in seconds) elapsed in the message transportation when it is a text message, a text message plus an attached picture and also with an attached video. The last two columns indicate whether the message content was successfully translated and also whether it was delivered through the right channel.

The results show that all messages were correctly translated to the format of the destination system and were also delivered through the channel preestablished by SMT for each pair of users. The time required to deliver a message showed to be suitable enough as to keep an asynchronous conversation between two people. Such a time is almost the same than the one required by a regular message to reach the destination, when it is directly sent through the selected channel (i.e., social interaction system). The evaluation results show that this time is more affected by the quality of the Internet access and the processing policies of social media systems, than by the SMT processing. For instance, in scenarios 4 and 12 we can see that sending a message of 5 MB through Skype requires less time than a message of 500 kB. This is because the policy of such a system is to compress large messages before sending them to the destination, which explains the results.

Other example of interference in this process is the quality of the Internet access, which is illustrated by the time spent to deliver a message weighting 500 kB through Gmail (scenarios 2, 4, 8, 10). Depending on the quality of this access, the transfer takes between 2.4 and 6.1 s for exactly the same message. Something similar happens with Telegram (scenarios 3, 5, 9, 11) and Skype (scenarios 1, 6, 7, 12) where the times are in the range of 0.9–2.8 s and 1.8–4.7 s respectively. The upper bound in this delay range seems to be around three times the best score. This pattern is not present when the message is large (e.g., weighting 5 MB).

These numbers also show the difference, in terms of time, taken by every social system to deliver the same message. Therefore, considering these situations we can expect that the extra time required by SMT for processing the message become invisible to end-users (it is estimated in 1 s in most cases).

Considering the suitability of the channel through which the message is received, in scenarios 13 to 24 we can see what happens when a user replies a message before 24 h of having received it. In that case, SMT delivers the answer using the same channel than the transmitter, which is a policy preestablished (configurable) in the translator. In scenarios 25 to 27 the response of the user was delivered after that deadline (i.e., 24 h from the last message), therefore the messages were routed to the channel preferred by the target user. That behavior also corresponds to what is expected for SMT.

Table 1. Summary of the empirical results.

Scenario #	Sender	Sending Channel	Responds to Scenario #	Receiver	Reception Channel	Text Msg	Txt + Pict (500 kB)	Txt + Video (5 MB)	Message Correctness	Channel Correctness
1	U1	Skype *	-	U4	ClientApp	1 s.	1.9 s	-	√	√
2	U2	Gmail *	-	U4	ClientApp	1	2.8	-	√	√
3	U3	Telegram *	-	U4	ClientApp	1	0.9	-	√	√
4	U1	Gmail	-	U4	ClientApp	1	6.1	18.7 s	√	√
5	U2	Telegram	-	U4	ClientApp	1	0.9	-	√	√
6	U3	Skype	-	U4	ClientApp	1	1.8	-	√	√
7	U1	Skype *	-	U4	ClientApp	-	4.7	4	√	√
8	U2	Gmail *	-	U4	ClientApp	-	4.9	11.9	√	√
9	U3	Telegram *	-	U4	ClientApp	-	2.8	6	√	√
10	U1	Gmail	-	U4	ClientApp	-	5.1	14.7	√	√
11	U2	Telegram	-	U4	ClientApp	-	1.9	4.8	√	√
12	U3	Skype	-	U4	ClientApp	-	4.1	4	√	√
13	U4	ClientApp	1	U1	Skype *	1	1.2	-	√	√
14	U4	ClientApp	2	U2	Gmail *	1	1.2	-	√	√
15	U4	ClientApp	3	U3	Telegram *	1	0.4	-	√	√
16	U4	ClientApp	4	U1	Gmail	-	2.9	6.9	√	√
17	U4	ClientApp	5	U2	Telegram	-	4.3	34.8	√	√
18	U4	ClientApp	6	U3	Skype	-	4.3	7.2	√	√
19	U4	ClientApp	7	U1	Skype *	-	3.6	6.3	√	√
20	U4	ClientApp	8	U2	Gmail *	-	4.1	6.1	√	√
21	U4	ClientApp	9	U3	Telegram *	-	4.6	34.7	√	√
22	U4	ClientApp	10	U1	Skype *	-	2.6	6.0	√	√
23	U4	ClientApp	11	U2	Gmail *	-	4.4	36.5	√	√
24	U4	ClientApp	12	U3	Telegram *	-	3.7	10.2	√	√
25	U4	ClientApp	4 delayed	U1	Skype * +	1	1.7	-	√	√
26	U4	ClientApp	5 delayed	U2	Gmail * +	1	1.4	-	√	√
27	U4	ClientApp	6 delayed	U3	Telegram * +	1	0.4	-	√	√
28	U4	ClientApp	7 delayed	U1	Gmail ** +	1	1.2	-	√	√
29	U4	ClientApp	8 delayed	U2	Telegram ** +	1	0.5	-	√	√
30	U4	ClientApp	9 delayed	U3	Skype ** +	1	1.6	-	√	√

*: Channel preferred by the destination user. **: New preferred channel after a preference change. +: A new version of the translator was used.

Scenarios 28 to 30 implemented tests similar to the last three previous scenarios, but before the transmitter delivers the response message, the destination user changes his channel preference. The results show that SMT delivers correctly the messages to the new preference of that user.

On the other hand, in the last six scenarios, new versions of the regular translators were used for each social interaction system. Therefore, we further simulated the process to add extra logic to the regular translator, as a way to address the natural evolution of these systems. As a result, in the three cases, the translator used the appropriate logic to translate the message and deliver it to the destination.

6.3. Discussion

The authors recognize that this evaluation process addresses only the technical aspects of the stated asymmetry problem, and that the human dimension should also be formally evaluated as part of future work. After clarifying this point, we can sustain that SMT can address the two main sources of asymmetries between the social media preferences of digital native and immigrant users.

The first 24 evaluation scenarios show the suitability of the SMT system to support the proposed translation in terms of correctness and performance. Scenarios 25 to 27 shows that the message routing rules embedded in SMT work well, and also that the system can use new versions of a translator as a way to deal with the natural evolution of the social interaction systems. Scenarios 28 to 30 shows the adaptability of the message translator to address the changes about the social interaction system preferred by a user to interact with other members of his community.

The related work shows several social tools that support interactions among digital natives and immigrants, and also systems that connects point-to-point these people through ad hoc solutions. Although useful, none of them addresses the asymmetry of social media preference and natural evolution of these systems shown in Section 3. This means that the digital immigrants have to either keep up with the pace of the technology and social scenario evolution or end up becoming digital orphans. In this sense, the SMT system represents a step forward towards the solution of this problem, providing mechanisms to conduct ubiquitous social interactions, particularly useful for digital immigrants.

7. Conclusions and Future Work

Technology advances, the lack of message exchange standards, and the growing complexity of social interaction scenarios, all inevitably produce an asymmetry in the social media preference of family members. Recent literature recognizes this asymmetry as an open problem that becomes evident when, for instance, two people want to communicate but do not share a common channel.

This work presents the Social Message Translator (SMT) system, which allows addressing part of this problem, translating messages between social media tools in a transparent way. This system consequently makes that client applications specially designed for digital immigrants can maintain the user interaction paradigm over time. This is almost regardless of the evolution of social media tools and the preferred applications by digital natives to interact with the immigrants.

The evaluation of the solution considered 30 message exchange scenarios. The obtained results show that the SMT system is capable, from a technical point of view, to deal with the technical evolution of social media tools and also with changes in the social media preference of the digital natives. This system should help reduce the number of digital orphans resulting from these two causes, due to the translator allows to digital immigrants to keep using the social interaction paradigms and tools that they learned to use time ago.

The next steps in this initiative consider evaluating the system during at least a couple of months, involving regular social media users belonging to digital native and immigrant populations. These experiments will allow us to determine the suitability of the system to mediate asymmetric social interactions from the users' point of view.

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