

Evolution of Publicly Disclosed Information in Facebook Profiles

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Abstract—With more than one billion subscribers, Facebook contains a huge amount of personal and sensitive information from its users. This personal information may be accessible to external entities/users based on users’ privacy configuration and/or due to external changes such as releasing of new policies or configuration by Facebook. This study aims to understand both *how the amount of available public information is evolving on the largest social network, Facebook, and the effect of the new Facebook profile layout appearance, “Timeline”, on this evolution?* To this end, we analyzed the evolution of disclosed information on 73K Facebook users’ profiles for a period of 5 months. We study both the overall evolution as well as user-based evolution, and the results show how the amount of available information changed on the 5 months period of our study.

Keywords—Online Social Networks; Facebook; Privacy Evolution; Information Disclosure.

I. INTRODUCTION

Facebook is the most popular On-line Social Network (OSN) with more than one billion subscribers. Users mainly utilize Facebook to share their opinions, interests, and personal content such as photos and videos with users who are connected to them. An important element that Facebook incorporates is the possibility of defining a detailed profile where users provide information about themselves. In Facebook we find more than 20 different attributes that can be filled out in a user’s profile. These attributes include potentially sensitive information such as contact info, birth date, current city, home town, employers, college, high school, etc. Furthermore, together with these personal details, Facebook users can complete their profiles by expressing their interests in different categories such as music, movies, books, television series, games, teams, sports, athletes, activities and inspirational figures, information which in many cases facilitates deriving sensitive information about a user (e.g. personality characteristics, political leanings). Depending on the person, her status and this information’s social context, publicly disclosing this sort of information could lead to some serious privacy issues. To avoid or at least mitigate privacy related problems, Facebook allows each user to define a degree of privacy for different attributes in the profile.

In case of filling the attribute, user can set its privacy level to (i) “only me” (ii) “friends” (iii) “friends of friends” (iv) “custom”, in this case the user can choose one by one the users who can access the attribute; and (v) “public”.

Based on the Facebook strategies by default most of the attributes are publicly available except the birthday, Political views, Religion and Contact Info that are in the level of “Friends”. For these attributes users can change the privacy level to public or more private. The information included in the profile of users is precious for external users/entities and these have very divergent objectives, from non-lucrative activities such as research to lucrative ones, including marketing campaigns. Given the privacy management provided by Facebook, external entities can only access attributes that have been defined as “public” by users.

Finally, it is worth noting that during this 5 months period, Facebook enforced the use of a new profile layout version known as “Timeline” [1]. This change in layout brought many discussion and privacy concern about the availability of users’ content as the default privacy configuration of some of the profile attributes changed to public [2].

Understanding the level of available information, and how this level and people concern are changing in time is an important aspect for different entities such as professional users [3] to consider in their marketing and advertising strategies.

Therefore the main research question that we aim to answer in this study is “*How is the evolution trend of publicly disclosed information in user profiles in a period of some months?*”. By answering this question we will be able to understand which type of information is considered more sensitive by Facebook users, and to the contrary, what the attributes are experiencing major public exposure and how the evolution of them is in a period of few months.

Toward this end, we have collected the public profiles of 73K randomly-selected Facebook users in two period of times with 5 months gap. The collected users are a subset of users that changed their layout to the “Timeline” in the period of data collection. Next, we analyzed 17 of the profile’s attributes by computing the portion of the collected users that publicly disclose each attribute in their profiles. We divide the attributes into two groups: *personal* and

interest-based attributes. The former category refers to attributes that contain personal life information about the user (e.g. location, education, work history, etc). Interest-based attributes, on the other hand reflect the tastes of Facebook users, revealed by their preferences (e.g. in music, television, sports teams, etc). The results will let us determine the attributes that users consider more sensitive.

In this paper, we first present an overall analysis of the evolution of disclosed information, which identifies the public exposure level of users. To this end, we have defined a very simple but meaningful metric that accounts for the number of attributes that are publicly disclosed in a Facebook profile, and refer to it as the *Degree of Public Exposure (DPE)*. The DPE ranges from 0 for user profiles that do not have any attribute publicly available, to 17 when a user has made all the analyzed attributes available, including personal and interest-based attributes. Hence, we can assign each of the 479K users in our dataset a DPE value. Using this metric and our dataset we are able to identify what type(s) of users present a higher degree of public exposure. In the second part, the evolution of public information is investigated based on three defined metrics: i) the transition of users' attributes degrees of openness, ii) the evolution of the DPE, iii) the ode degree and the Interest degree, which show us the actual amount of change in each metric during the period of the study.

The main observations extracted from this paper are:

- (i) The Release of the new "Timeline" layout in Facebook and the enforcement to migrate to this new layout by Facebook had a clear effect on privacy evolution. In general this event increased the percentage of attribute disclosure and also brought users' attention to some specific attributes in order to change the privacy configuration of those attributes.
- (ii) Facebook users are becoming more concerned about potential privacy risks for some of the important attributes in their profiles. Our analysis reveals that around 18% of Facebook users have decided to close (i.e. make private) their friends-list, while only 1.5% changed it to public in the period of our study.
- (iii) Although there was a significant update in the privacy level of each user's profile, the number of public attributes remained stable in general. More than four attributes are public in users' profile.
- (iv) Friends-list is the attribute with the largest public exposure in the first snapshot with almost 60% of users publicly sharing their contacts but it drops by 16.44% to 43% after 5 months; whereas users' age (i.e. Birth date attribute) as the highest privacy value for Facebook users, since only 3% disclose this information.
- (v) Although we found a small portion of users who decrease their number of friends in the period of data collection, but almost all of the users increase their social graphs by adding new friends and on median (average), users added 44 (77) friends in a 5 months period.

The rest of this paper is organized as follows: Section II summarizes the related work and Section III describes our data collection techniques as well as the attributes' definitions. Section IV discusses the overall evolution of disclosed information on Facebook profiles and section V presents a user-based analysis and finally we conclude the paper in Section VI.

II. RELATED WORK

The prior efforts related to this paper can be divided into two categories as follows:

Information Disclosure in Social Networks. There are several studies that investigate the level of information disclosure in social networks focusing on a group of users from a specific country [4], [5] or city [6] or users from a university [7] but only a few studies that look on a random sample of users [8] are available. Conceptually similar to our study, Quercia et al. (2012) [4] found a correlation between the degree of openness and gender, using a dataset of 1323 profiles from the United States. Our work has many distinctions from this study. Firstly, our dataset is much larger and broader (73K profiles widely distributed throughout the world compared to a little more than 1K profiles exclusively from U.S.). Secondly, our data was gathered directly from Facebook profiles, while Quercia et al. used a form of questionnaire administered by a specific Facebook application. Lastly, we study most of the available attributes in the FB profiles, and for some of them we deeply investigated the correlation between the attribute type and profile characteristics. They also concluded that men tend to make their profile information more publicly available.

Gross et al. studied the patterns of information revelation in Facebook [7]. They analyzed around 4K Carnegie Mellon University students' profiles, specifically those that joined a popular social networking site catering to college students. Gross et al. evaluate the amount of information students disclose and their usage of the site's privacy settings. Researchers also studied the evolution of the profiles privacy of around 5k of their collected profiles [9]. In other work, Chang et al. [5] studied the privacy attitudes of U.S. Facebook users of different ethnicities. Using a questionnaire, another U.S.-based study [10] that considered 1,710 students' profiles showed that women are more likely to maintain a higher degree of profile privacy than men; and that having a private profile is associated with a higher level of online activity.

Authors in [11] examined disclosure in Facebook profiles looking at only 400 Facebook profiles. In a similar work, the authors in [12] employed surveys and interviews to study the factors that influence university students to disclose personal information on Facebook. In addition, we studied the amount of information disclosed on Facebook profiles in a dataset including half a million users [8]. In addition, some other studies provide methodologies which use publicly-available

Facebook users' profile attributes to do different types of estimation or prediction such as estimating a user's birth year [6], predicting friendship status [13] or predicting the attributes of another user [14].

Privacy Evolution in Social Networks. There are several studies on the different aspects of privacy in social networks, from the general formulation of privacy concerns in social networks [15], [16], to design issues [17] and the possible negative impacts of social networking sites on their users [18], as well as works that investigate the privacy and security of users in online social networking sites such as: Facebook, Google+, and Twitter [19]. Regarding the evolution of social network information, [20] presents the results of analyzing a timestamped dataset describing the initial growth and evolution of a large social network in China. The changes in default profile settings over time and the evolution publicly-available Facebook data are discussed in [21], based on the author interpretation of the Facebook Terms of Service over 6 years. In another work focused on the goal of better understanding the Facebook social network, [22] investigates the role of directed interaction between pairs, such as wall posts, comments, and "likes" and consumption of friends' content, including status updates, photos, and friends' conversations with other friends.

To understand the effect of a new feature on users' privacy trends, the authors in [23] studied the introduction of two Facebook's features (News Feed and Mini Feed) on users' profiles. More similar to our work, an investigation of Facebook users' privacy evolution in a large sample of New York City (NYC) Facebook users, is presented in [24]. That study shows how the close/open status of profiles' attributes changed over time. Although the general concept of that work is similar to our study, but there are several differences. One major difference is that their dataset only includes US-based users, while our users are randomly selected and are distributed throughout the world. Another big difference is that we have looked at the amount of information that is publicly available and the evolution trend of that amount, as well as the effect of major changes in this trend and principle profile attributes, but in that study the focus is only on certain attribute's transitions from public to closed and vice versa.

Considering the previous studies, based on authors knowledge the work presented here provides new insight on how privacy concern of people is evolving based on a large dataset from Facebook profiles to analyze the evolution of profile information disclosure.

III. DATA COLLECTION AND ATTRIBUTES DEFINITION

We have developed an HTML crawler that is able to collect publicly-available information from a Facebook user's profile [8]. The crawler collects up to 17 attributes from each profile. It must be noted that our tool respects the privacy of users since we only collect information that users themselves have decided to share publicly. Since we can only

collect publicly-shared information, we cannot distinguish if an attribute is blank or if it is closed to the public.

Our goal is to capture the publicly available information from a random sample of Facebook profiles in two snapshots. We ran our crawler and captured the profile of 73k Facebook users randomly selected throughout the world, in two snapshots separated by 5 months, February 2012 (1-Feb) and July 2012 (2-July). It worth mentioning that all of the selected users were using the old Facebook layout in the first snapshot and that all had changed to the "Timeline" layout by the time of the second snapshot. For each user we store up to 17 different attributes (only those that are publicly available). We classify those attributes into two categories: personal and interest-based. The first category refers to information related to an individual's life, and the second includes information regarding user's "likings". The 17 attributes are listed below in their respective category.

Personal attributes: Friends-list, Current City, Hometown, Gender, Birthday, Employers, College.

Interest-based attributes: Music, Movies, Books, TV shows, Games, Teams, Athletes, Activities, Interests and Inspired people.

The meanings of the personal attributes above are obvious and self-contained. It is worth mentioning that some attributes, such as *Employers* or *College*, can include more than one item. For instance, a user can include the current employer as well as the previous ones or, in the case of college, a user could list several names if she obtained degrees from different universities or other post-secondary schools. In the case of Interest-based attributes, all of them can contain more than one item. Facebook users use these attributes to express their likings for the categories referred by the attribute. For instance, in the music category we can find singers, music bands, music styles (e.g. jazz, rock, etc.), music albums, etc. We need to note that in our analysis we insert an "artificial" interest-based attribute, called *Aggregate-Interests* which is a binary attribute. It is 1 if the user publicly shares at least one item among all the interest-based attributes, and 0 otherwise. The *Aggregate-Interests* attribute will show us if a user shares any interests without taking into account the separate categories.

Finally, in order to perform personal attribute correlations, and to gain further insights into some of them, we have divided our main dataset into several attribute-based groups. Basically, a given group A includes all the users in our main dataset that publicly disclose attribute A . For instance, from this point onwards in the paper, when we mention the *Gender* group we are referring to the group that includes all the users in our dataset that make their gender publicly available in their Facebook profile.

A. Ethics Considerations

Although we only collected publicly available data from the randomly selected Facebook users' profile, we incor-

Table I
EVOLUTION OF THE PORTION OF USERS WITH PUBLICLY DISCLOSED PERSONAL AND INTEREST-BASED ATTRIBUTES IN FACEBOOK PROFILES IN TWO SNAPSHOTS.

Attribute	1-Feb (%)	2-July (%)	DIFF(July - Feb) (%)
Friends-list	60.10	43.66	- 16.44
CurrentCity	33.38	40.34	6.96
Hometown	30.93	31.71	0.78
Gender	54.96	80.18	25.22
Birthday	3.27	3.46	0.19
Employers	21.17	19.80	- 1.37
College	15.92	18.14	2.21
Aggregated-Interests	47.32	49.54	2.23
Music	40.45	42.27	1.82
Movies	27.56	29.45	1.89
Books	15.96	18.13	2.17
TV shows	30.66	32.90	2.24
Games	9.99	12.21	2.21
Teams	8.82	15.56	6.73
Athletes	11.50	17.24	5.74
Activities	20.95	23.22	2.27
Interests	9.32	13.33	4.01
Inspire	1.76	2.54	0.78

porated a few steps to protect user privacy: all data were encrypted at rest and not re-distributed, no personal or sensitive information was extracted, and we only analyzed aggregated statistics.

IV. OVERALL EVOLUTION OF DISCLOSED INFORMATION

In this section we define the degree of publicly disclosed information in Facebook¹.

A. Evolution of the attributes' disclosure degree

In this subsection, we analyze the degree of public availability of the different attributes. Our goal is to determine how the level of privacy awareness that Facebook users present is changing. Table I shows the portion of users that publicly disclose each of the studied attributes in two snapshots as well as the difference between the percentage from the second snapshot (*2_July*) and the first one (*1_Feb*).

As shown in the table, except for two attributes (*Friends-list* and *Employers*), almost all of the attributes have a slight increment in their values and the highest increment is for the *Gender* attribute with a 25% increase in the disclosure percentage. This increase is due to the appearance of the "Timeline" layout which made some of the attributes more public than before. If users did not want to keep them public they would have to manually change the privacy configuration [2]. On the other hand, the openness of *Friendslist* attribute decreased by 16%, which shows that Facebook users are more concerned about their friends-list than they are about revealing their gender, and shows their

¹We clarify that, for better readability, in the rest of the paper when we mention that a user discloses, shares or makes available an attribute we are explicitly saying that this attribute was assigned a privacy level of "public" and so any other user has access to it.

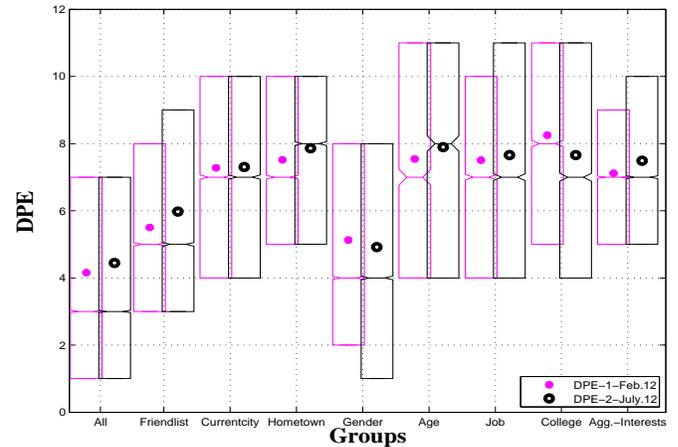


Figure 1. Box plot of DPE distribution for groups in two snapshots (1-Feb & 2-July) [the dot point inside each plot shows the average value].

tendency to close it. In the Interest attributes, the results show that users are disclosing their interests list, and in general, the users who disclose at least one of the attributes in the interests list, increased by 2.2%.

B. Evolution of the users' information disclosure degree

To this point we have performed an attribute-based analysis that has allowed us to understand how the portion of disclosed attributes changed over a period of 5 months. However, this analysis did not account for the evolution of the public exposure of Facebook users. Towards this end, we need to perform a user-based analysis of two snapshots. Instead of taking one attribute and counting how many users share it, we now need to look at individual users and determine how many attributes (among all those possible)

each one is disclosing. For that we take into account all 17 attributes collected with our tool from a Facebook profile (Personal + Interest-based attributes). We used a metric which we have defined in a previous work [8] called the Degree of Public Exposure (DPE), which ranges from 0 to 17. Basically, we go through the 17 parameters and whenever one can be accessed we sum +1 to the DPE value for that user. By defining this metric we are able to easily compare the level of profile’s attribute openness without considering any kind of difference between the attributes.

We will refer as *All*, the group formed by all the users in our dataset that includes 73K profiles, and as *ATTR group* the group included all the users who have disclosed that specific attribute (ATTR). We provide some numbers that paint a global picture of the amount of information (i.e. attributes) is made publicly available by Facebook users.

Figure 1 provides further details of the DPE distribution for the different groups by means of a box plot graph that shows the 25th, 50th (median) and 75th percentiles, where the dot point inside each plot shows the average value of the DPE metric for the ALL group, as well as each of the previous attribute-based groups in both snapshots.

If we first consider the result for the *All* group, it shows that the amount of available information did not change and on median 3 attributes are available out of 17 under study. But in average we see a slight increase (0.3%) on the DPE value from the first to the second snapshot. We saw the same pattern in three other groups (*Friends list*, *CurrentCity* and *Employers*).

Interestingly the *College* group is the only group that shows a decrease around one attribute in both the median and average, which can be interpreted as implying that users who disclosed their educational information on their Facebook profile are reducing the amount of publicly available information on their profile.

On the other hand, the DPE degree of users in the *Age* group is increased in both the median and average. A previous study [8] showed that the age range most-represented, based on publicly available information, is 18-25. That range accounts for 1/2 of the users among those making their birth date publicly available which shows that young people show less concern about disclosing their profile information.

V. USER-BASED EVOLUTION OF DISCLOSED INFORMATION

Having performed an overall analysis to understand the privacy evolution and assess the degree of disclosure per attribute, in this section we turn into a user-based analysis and study the information disclosure evolution per user.

A. Transition of users’ attributes openness

For each personal attribute as well as interest-based attributes, Table II shows the portion of users that transitioned that

attribute’s status from (Open -> Close) or vice versa (Close -> Open) or their openness status remained unchanged. The first and more important result is that around 18% of Facebook users decided to close (i.e. make private) their friends list information while only 1.5% make it public in the analyzed period after the change in the layout to “Timeline”. This trend demonstrates that Facebook users are becoming more concerned about potential privacy risks associated with the fact that any person can know your list of contacts. This concern is shown by the large number of users making their list of friends closed to the public, and the low number of those who have opened their lists.

In contrast, we find a different trend for the *Gender* attribute. In this case, only 1.3% make it private and more than 1/4 of users made their gender attribute publicly available. Generally, this is not a very sensitive attribute, as gender can be easily extracted from other sources such as the username, pictures (if available), etc. Furthermore, it is very interesting to observe that almost 9% of users decided to make their *Current City* public, which demonstrates that Facebook users are somehow relaxing their concern about providing location information. However, contrary to what we demonstrated in a previous work [8] that there is a correlation between *Current City* and *Home Town* attributes, we now see that the portion of users that make their Hometown available (only 2.5%) is much smaller than those who decide to set their *Current City* availability to open (8.8%).

In the case of *employers* the balance is slightly negative as we find more users setting this information as private (4.5%) than opening it (3.2%). In the case of *Aggregated-Interests* the balance is slightly positive since 4.5% users that did not have any *Likes* on 1-Feb showed at least one on 2-July snapshot, while only 2.3% removed that information from public users’ access. The similar thing happened for the *College* attribute, where 6.3% of the users went from (Closed -> Open) and 4.1% from (Open -> Closed).

B. Evolution of DPE

Next we aim to understand how the amount of public information (DPE value) has changed per user. To this end, we use the defined groups based on their attributes, as detailed in subsection IV-B. For each user we compute the DPE difference between the 1-Feb and the 2-July snapshots. This metric shows us how the DPE has been changing over 5 months; if the difference value for a user is positive it means that she has more public attributes in the July snapshot than she had in February, thus she is incurring an increment of her public exposure. The higher the difference the larger the evolution in her public exposure, and vice-versa. This analysis allows us to determine if FB users have become more public or more private within the 5 months’ time window under analysis.

Figure 2 depicts the CDF for the DPE difference between 1-Feb and 2-July, and Table III shows the portion of users

Table II
TRANSITION IN THE PROFILE GENERAL ATTRIBUTES (PERSONAL INFORMATION) PER GROUPS, ALL VALUES ARE IN PERCENTAGE (%).

Attributes	Open -> Close	Close -> Open	Open -> Open	Close -> Close
Friendlist	17.9	1.5	42.2	38.4
CurrentCity	1.9	8.8	31.5	57.8
Hometown	1.7	2.5	29.2	66.6
Gender	1.3	26.6	53.6	18.5
Birthday	0.3	0.5	3.0	96.2
Employers	4.5	3.2	16.6	75.7
College	4.1	6.3	11.9	77.8
Agg.-Interests	2.3	4.5	45.0	48.1
Music	2.1	4.0	38.3	55.6
Movie	1.8	3.7	25.8	68.7
Book	0.9	3.1	15.1	81.0
TV	1.6	3.9	29.0	65.5
Games	0.8	3.0	9.2	87.0
Team	0.6	7.3	8.2	83.9
Athletes	0.8	6.5	10.7	82.0
Activities	1.2	3.5	19.7	75.6
Interests	0.4	4.4	8.9	86.2
Inspire	0.1	0.9	1.6	97.3

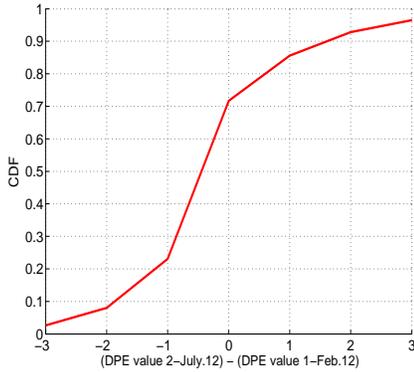


Figure 2. CDF of the change in the profiles' DPE value

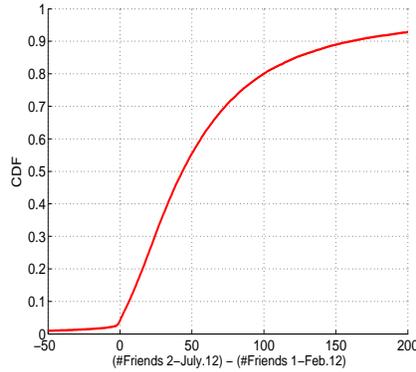


Figure 3. Change in the #Friends for profiles with Open Friend List (Open -> Open)

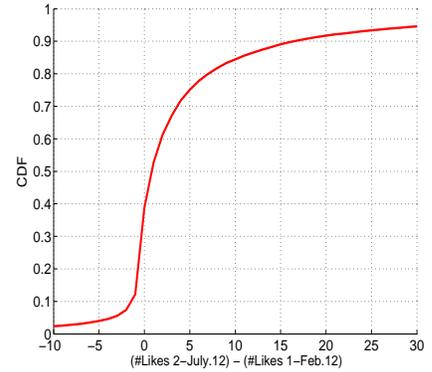


Figure 4. Change in the #Likes for profiles with Open Likelist (Open -> Open)

that have increased, have decreased or have kept constant their DPE value. The results show that around 1/2 of the users do not show any DPE change in their profile. This means that half of the Facebook users did not modify their privacy for the attributes in their profile in the period of study. Furthermore, the portion of users that became “more public” is slightly higher (28%) than that of users who became less public (23%). These results reveal that, although there are important updates at the user profile level, overall there is not any clear trend which can represent the increasing (or decreasing) public availability of users' profiles. In nutshell the overall amount of public information from Facebook profile attributes remained stable.

C. Evolution of Node Degree

Moving from a privacy analysis, we want to use the defined groups to understand how the number of friends evolves in Facebook over a period of a few months. Figure 3 shows the difference in the number of friends for the users

Table III
PERCENTAGE OF USERS THAT HAVE DECREASED, INCREASED OR NOT CHANGED THEIR DPE VALUE IN THE 5 MONTHS PERIOD OF THE STUDY.

	% Increase	% Decrease	% No Change
Users	28.32	23.08	48.60

between the 1-Feb and the 2-July snapshots. As indicated, very few users (less than 4%) have reduced their number of friends, and even fewer have kept the same number of Friends (less than 1% for all the groups). This means that more than 95% of the users have increased their contacts list by adding new friends.

We found that on average (median), a regular Facebook user added 77 (44) new friends in her friends list. This gives a clear message that Facebook was a very dynamic network at the time of the study when multiple new links were still being established. We must take into account that while collecting our dataset we did not focus on gathering any

type of Facebook users in terms of to their account creation time; therefore, even if we do not have that information it is very likely that the account creation of those users in our dataset is distributed uniformly over the studied time, and thus the obtained average number is very representative of the dynamism of Facebook.

D. Evolution of Interest Degree

Following the previous experiment on the friends list, here we aim to measure whether Facebook users tend to increase their interest by adding and following new interests to their interest list or not. Figure 4 shows the CDF for the difference between the number of interests a user had available on 1-Feb and on the 2-July snapshot². The result shows a large portion of users, 61%, increased the number of interests they share publicly and in average 6 interests were added to the profiles during the 5 month period.

In a nutshell, in terms of privacy (understood as profile attributes publicly disclosed), if we look at the forest (i.e. overall attributes information available on Facebook in relative terms) we do not find a substantial difference between two snapshots as the evolution of DPE states. However, if we look at the trees (i.e. Facebook users) we can observe a very important variability where more than 1/2 of the users have changed their publicly available information in a 5 month period.

VI. CONCLUSION

In this paper we study the evolution of publicly-available information of 73K Facebook users within a period of 5 months, during which a significant change in the layout of Facebook profiles also occurred with the release of the “Timeline” layout. The main insights from this study is as follows: (i) The general evolution result reveals that although there are important updates at the user profile level and almost half of the users changed their level of publicly-available information in the 5-months period, but the amount of publicly-available information from Facebook profile attributes remained stable; and (ii) Facebook users are becoming more concerned about the potential privacy risks of some important attributes such as their friends list which 16% of users closed to public access. As to the future directions of this investigation, we aim to discover and understand the influential factors that affect users’ privacy changes, and how a major change on the real life of a user (e.g. changing city, job, marital status, etc.) affects the amount of information disclosed in their profile.

²We only take into account those users that publicly share at least one interest in both datasets.

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