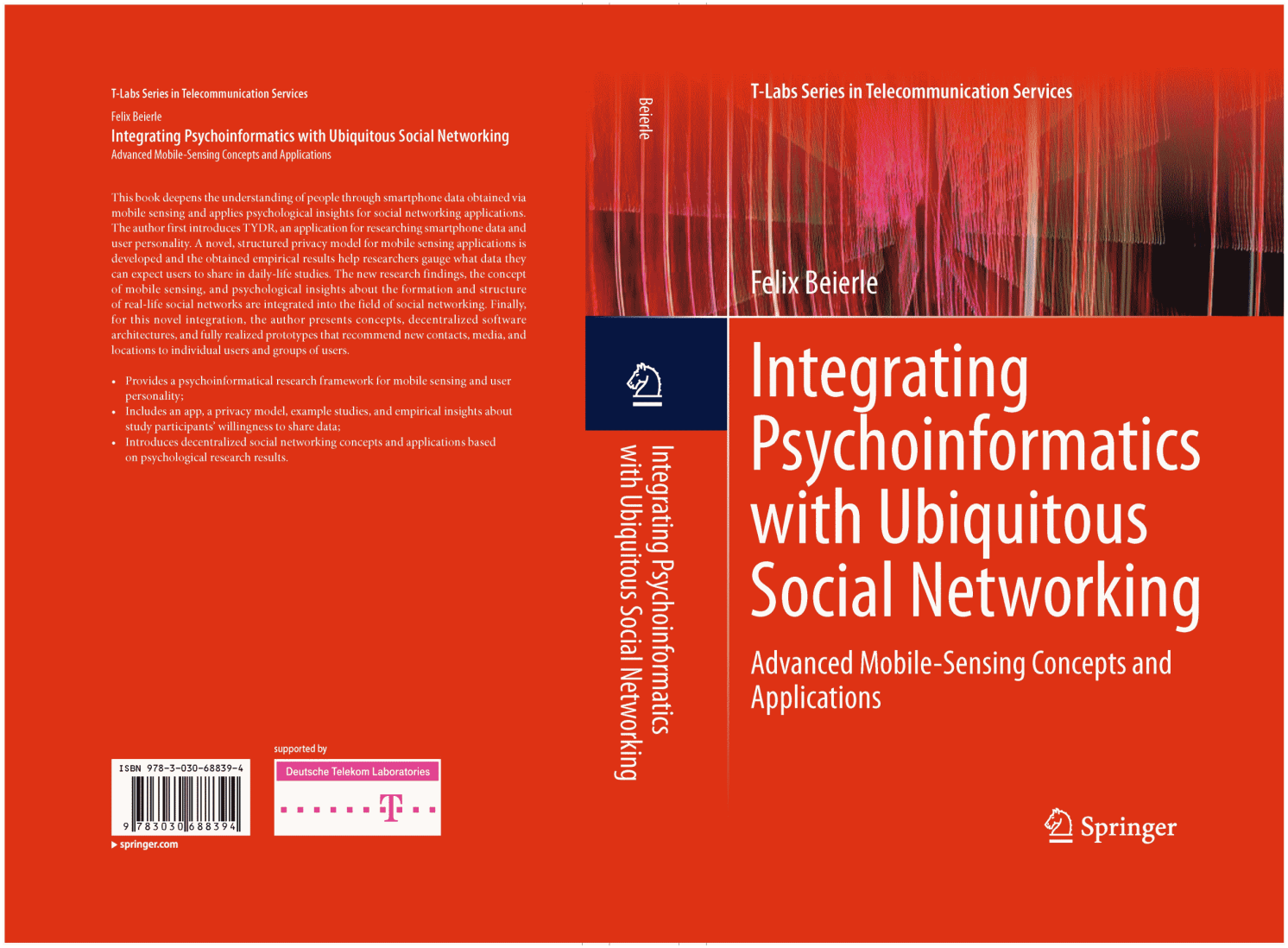

Integrating Psychoinformatics with Ubiquitous Social Networking

Advanced Mobile-Sensing Concepts and Applications

vorgelegt von
M.A., M.Sc.
Felix Beierle
ORCID: 0000-0003-2702-9893

an der Fakultät IV – Elektrotechnik und Informatik
der Technischen Universität Berlin
zur Erlangung des akademischen Grades

Doktor der Naturwissenschaften
- Dr. rer. nat. -

genehmigte Dissertation

Promotionsausschuss:

Vorsitzender:	Prof. Dr.-Ing. Sebastian Möller, Technische Universität Berlin
Gutachter:	Prof. Dr. Axel Küpper, Technische Universität Berlin
Gutachter:	Prof. Dr. Rüdiger Pryss, Julius-Maximilians-Universität Würzburg
Gutachter:	Prof. Dr.-Ing. Jöran Beel, Trinity College Dublin

Tag der wissenschaftlichen Aussprache: 23. Juni 2020

Berlin 2020

Abstract

There are fundamental differences in the way people experience behaviors and emotions. The field of *psychometrics* allows the quantifiable measurement of *personality traits* that describe such inter-personal differences. Vast amounts of psychological and psychoinformatical studies show that personality traits are not only associated with different everyday preferences, but also with the way people form interpersonal bonds in social networks. However, these research results are rarely considered in the research and development of social networking services. We argue that such understanding of people, their behaviors, emotions, and how they form bonds with other people can be integrated in social networking services and may ultimately improve real-life social well-being. The objective of this doctoral thesis thus is the integration of *psychoinformatics* – the intersection of psychology and computer science – with ubiquitous social networking.

Psychoinformatics uses objective measurements to research and deepen the understanding of personality-related differences in human experiences and behaviors. A common approach is *mobile sensing*. Such tracking of sensor data has serious implications regarding the privacy of users. However, currently, there are no structured approaches in dealing with these privacy concerns. Furthermore, when planning a psychoinformatical study, it is unclear to what extent demographical properties and personality traits play a role when collecting data from daily life scenarios. We develop a structured approach for privacy-awareness for mobile sensing in psychoinformatics and conduct a study on what data researchers can expect users to be willing to share. Our results can help researchers with study planning, and study participants benefit by increased privacy-awareness. While there have been several studies related to personality traits and smartphone data, there are knowledge gaps, specifically with regard to smartphone usage frequency and duration in relation to the user's personality. We collect and analyze data and fill this gap. Our results are valuable for psychologists, for example, when researching smartphone overuse. Additionally, our results help researchers and software developers of mobile systems understand their user base better.

In particular, we designed, developed, and deployed the Android app TYDR – Track Your Daily Routine – for the collection of smartphone sensor and usage data. We developed and implemented PM-MoDaC, a full-scale privacy model for mobile data collection apps, consisting of nine different technical and design-related measures. We

released TYDR on Google Play and attracted nearly 4,000 users. Evaluating our privacy model, we analyze what data users are willing to share with researchers, for example, younger users tend to be less willing to share data. We conduct a study analyzing the relationship between personality traits and smartphone usage frequency and usage session duration. On average, the users in our sample (n = 526) used their smartphone 72 times per day, with a mean session duration of 3.7 minutes. Our study reveals that neurotic and extraverted users use their phone more frequently while conscientious users have shorter session durations.

We integrate psychoinformatics with ubiquitous social networking by developing concepts, metrics, and applications that are based on mobile sensing and consider psychological insights about real-life social networking. Most existing systems rely on manually entered profile data, making them tedious to use. Our results are highly automated unobtrusive ubiquitous social networking systems that may help improve social well-being by providing smartphone-mediated incentivizations of social interaction, and by seamlessly providing services to individual users and groups of users. Users benefit from our systems' high degree of automation and their unobtrusiveness, and from potentially more meaningful smartphone-mediated real-life social networking. Our concepts, metrics, and prototypical applications serve as blueprints for researchers and developers of similar systems.

In particular, we develop SimCon, a concept for the recommendation of new contacts. Similar people in proximity are recommended based on similar smartphone data. To estimate the similarity between two users, we introduce the metric CBF-Dice utilizing probabilistic data structures. CBF-Dice is able to accurately asses similarity with a single exchange of a small Counting Bloom Filter. Furthermore, we develop two full ubiquitous social networking app prototypes. MobRec, our platform for decentralized recommender systems, is based on device-to-device data exchange and runs on both Android and iOS on off-the-shelf smartphones. Implicit preferences and explicit ratings are exchanged when users are in proximity. Local recommender system or third-party service providers then recommend new items based on on-device data. GroupMusic, our group recommender system, is based on mobile sensing and privacy-aware sharing of data. It implements a ubiquitous computing vision: fully automatically, the system plays back music for a group of currently present users.

Zusammenfassung

Es gibt fundamentale Unterschiede in der Art und Weise, wie Menschen Verhalten und Emotionen wahrnehmen. Das Feld der *Psychometrie* erlaubt die quantifizierbare Messung von *Persönlichkeitsmerkmalen*, welche solche inter-personellen Unterschiede beschreiben. Eine erhebliche Anzahl psychologischer und psychoinformatischer Studien zeigen, dass Persönlichkeitsmerkmale nicht nur mit Alltagspräferenzen verbunden sind, sondern auch damit, wie Menschen interpersonelle Beziehungen in sozialen Netzwerken aufbauen. Jedoch werden diese Forschungsergebnisse in der Erforschung und der Entwicklung von *Social Networking* Diensten kaum in Betracht gezogen. Wir argumentieren, dass solch ein Verständnis von Menschen, von ihrem Verhalten, von ihren Emotionen und davon, wie sie Beziehungen mit anderen Menschen eingehen, in Social Networking Dienste integriert werden kann und so letztendlich das soziale Wohlergehen verbessern könnte. Das Ziel dieser Dissertation ist deswegen die Integration von *Psychoinformatik* – die Schnittmenge aus Psychologie und Informatik – und *Ubiquitous Social Networking*.

Psychoinformatik verwendet objektive Messungen, um das Verständnis von persönlichkeitsbezogenen Unterschieden in menschlichen Erfahrungen und Verhalten zu erforschen und zu vertiefen. Ein gebräuchlicher Ansatz ist *Mobile Sensing*. Solch ein Verfolgen von Sensordaten hat ernsthafte Implikationen bezüglich der Privatsphäre der Nutzer*innen, jedoch gibt es zurzeit noch keine strukturierten Ansätze, um mit diesen Privatsphärebedenken umzugehen. Des Weiteren ist bei der Planung von psychoinformatischen Studien unklar, bis zu welchem Grad demographische Eigenschaften und Persönlichkeitsmerkmale eine Rolle beim Sammeln von Daten aus dem Alltag spielen. Wir entwickeln einen strukturierten Ansatz für ein Privatsphäremodell für *Mobile Sensing* in der Psychoinformatik und führen eine Studie darüber durch, welche Bereitschaft zum Teilen von Daten Forscher*innen erwarten können. Unsere Ergebnisse helfen Forscher*innen bei der Studienplanung und Studienteilnehmer*innen profitieren von erhöhtem Datenschutzbewusstsein. Obwohl es schon einige Studien zu Smartphonedaten und Persönlichkeitsmerkmalen gibt, gibt es noch Wissenslücken, speziell in Bezug auf Smartphonenutzungsfrequenz und -nutzungssitzungsdauer im Verhältnis zur Persönlichkeit des/der Nutzer*in. Wir

sammeln und analysieren Daten und füllen diese Lücke. Unsere Ergebnisse sind wertvoll für Psycholog*innen, zum Beispiel, wenn sie übermäßige Smartphonenutzung erforschen. Zusätzlich können unsere Ergebnisse auch Forscher*innen und Softwareentwickler*innen von mobilen Systemen helfen, ihre Nutzer*innenbasis besser zu verstehen.

Wir entwerfen, entwickeln und nutzen die Android Anwendung TYDR – Track Your Daily Routine – zur Sammlung von Smartphonesensor und -nutzungsdaten. Wir entwickeln und implementieren PM-MoDaC, ein umfassendes Privatsphäremodell für Anwendungen, die sich mit der Sammlung mobiler Daten befassen. Es besteht aus neun verschiedenen technischen und entwurfsbezogenen Maßnahmen. Wir haben TYDR bei Google Play veröffentlicht und ca. 4.000 Nutzer*innen gewonnen. Wir evaluieren das Privatsphäremodell und analysieren, welche Daten Nutzer*innen bereit sind, mit Forscher*innen zu teilen. Zum Beispiel sind jüngere Nutzer*innen tendenziell weniger dazu bereit, Daten zu teilen. Wir führen eine Studie durch, die die Beziehung zwischen Persönlichkeitsmerkmalen und Smartphonenutzungsfrequenz und -dauer analysiert. Im Schnitt benutzen die Nutzer*innen unserer Stichprobe (n = 526) ihr Smartphone 72 Mal am Tag, mit einer durchschnittlichen Sitzungsdauer von 3,7 Minuten. Unsere Studie zeigt auf, dass neurotische und extravertierte Nutzer*innen ihr Smartphone öfter verwenden, während gewissenhafte Nutzer*innen kürzere Nutzungssitzungen haben.

Wir integrieren Psychoinformatik in Ubiquitous Social Networking durch das Entwickeln von Konzepten, Metriken und Anwendungen, die auf Mobile Sensing basieren und die psychologische Erkenntnisse darüber berücksichtigen, wie Menschen im echten Leben soziale Netzwerke bilden. Die meisten existierenden Systeme beruhen auf manuell eingegebenen Profildaten, was deren Nutzung mühsam macht. Unsere Ergebnisse sind höchst automatisierte, unaufdringliche, allgegenwärtige Ubiquitous Social Networking Systeme, die helfen könnten, das soziale Wohlbefinden zu verbessern, indem sie Smartphone-vermittelte Anreize für soziale Interaktionen zur Verfügung stellen und Dienste für individuelle Nutzer*innen und Gruppen von Nutzer*innen bereitstellen. Nutzer*innen profitieren von dem hohem Grad an Automatisierung unserer Systeme und ihrer Unaufdringlichkeit und von potentiell bedeutungsvolleren Smartphone-vermittelten sozialem Miteinander. Unsere Konzepte, Metriken und prototypischen Anwendungen dienen als Blaupausen für Forscher*innen und Entwickler*innen von ähnlichen Systemen.

Wir entwickeln SimCon, ein Konzept für die Empfehlung von neuen Kontakten. Menschen in der Nähe werden basierend auf der Ähnlichkeit ihrer Smartphonedaten empfohlen. Um die Ähnlichkeit von zwei Nutzer*innen abzuschätzen, führen wir die Metrik CBF-Dice ein, die probabilistische Datenstrukturen verwendet. CBF-Dice kann die Ähnlichkeit mit dem einfachen Austausch eines Counting Bloom Filters korrekt abschätzen. Des Weiteren entwickeln wir zwei vollständige Ubiquitous Social Networking Prototypen. MobRec, unsere Plattform für dezentralisierte Empfehlungssysteme, basiert auf Gerät-zu-Gerät Datenaustausch und läuft auf handelsüblichen Android- und iOS-Smartphones. Implizite Präferenzen und explizite Bewertungen werden ausgetauscht, wenn Nutzer*innen in der Nähe voneinander sind. Lokale Empfehlungssysteme oder externe Dienstanbieter*innen können dann neue Objekte auf Basis der lokalen Daten empfehlen. Unser Gruppenempfehlungssystem GroupMusic basiert auf Mobile Sensing und dem datenschutzbewussten Teilen von Daten. Es implementiert eine Vision des Ubiquitous Computing: Das System spielt vollautomatisch Musik für eine Gruppe gerade anwesender Nutzer*innen ab.

Acknowledgments

This doctoral thesis would not have been possible without other people's support, advice, and productive collaborations. First of all, I'd like to thank my supervisor Prof. Dr. Axel Küpper for his continual support and guidance over the last years. His advice and feedback was indispensable to my work. I would also like to thank Prof. Dr. Rüdiger Pryss for his helpful advice and feedback, and for always supporting me and my ideas. I also thank Prof. Dr. Jöran Beel for his valuable advice that helped me grow as a researcher, and for inviting me for a research visit to the National Institute of Informatics (NII) in Tokyo.

Working in such an interdisciplinary field as psychoinformatics, I'm thankful for the great collaborations with psychological researchers, specifically with PD Dr. Winfried Schlee, Dr. Patrick Neff, Prof. Dr. Mathias Allemand, Prof. Dr. Thomas Probst, Prof. Dr. Johannes Zimmermann, Prof. Dr. Stefan Stieger, and Dr. Sanja Budimir. I would also like to thank Prof. Dr. Yang Chen, Prof. Dr. Pan Hui, and Prof. Dr. Akiko Aizawa for their advice and for inviting me to give presentations about my work in their groups at Fudan University in Shanghai, at Hong Kong University of Science and Technology (HKUST), and at the National Institute of Informatics (NII), Tokyo.

I am grateful for all the lively discussions and mutual support with my colleagues at Technische Universität Berlin. I like to especially thank my colleagues who co-authored papers with me related to this thesis, Kai Grunert, Dr. Sebastian Göndör, and Tobias Eichinger.

Over the years, many students were part of the TYDR team. First, I'd like to thank Vinh Thuy Tran for all his efforts and his resourcefulness. I also especially thank Soumya Siladitya Mishra, Sarjo Das, Sakshi Bansal, Marcel Müller, Yong Wu, and all my other student assistants. I am also grateful for all the feedback I got from friends and colleagues during the development of TYDR. I owe a special thanks to Daniel Lenz and all TYDR users. During my time as a PhD student, I had the chance to supervise several bachelor's and master's theses. In particular, I thank Robert Staake, Jan Pokorski, Simone Egger, Viktor Schlüter, Hai Dinh Tuan, Julian Tan, and Ishan Tiwari for their great theses.

The German Federal Ministry of Education and Research (BMBF) and the Software Campus program funded my project out of which I created TYDR. The Software Campus

program and its funding played a major role in my ability to pursue my own research project. I'd like to extend my thanks to Andrea Hahn and Sandra Wild for their support in navigating the intricacies of university bureaucracy.

Finally, I'd like to thank all my friends and my family, especially my parents, who always supported me in my endeavors.

Berlin, Germany Felix Beierle

Contents

1 Introduction

Psychological research shows that there are fundamental differences between people and how they experience behaviors and emotions. Not only does this affect individual experiences but also the forming of interpersonal relationships. Applying these findings in smartphone-mediated social networking services may help improve social well-being. This thesis aims at the integration of *psychoinformatics* and *ubiquitous social networking* and makes contributions in both of these fields.

1.1 Psychoinformatics

The emerging field of *psychoinformatics* is at the intersection of computer science and psychology. It primarily focuses on the collection and analysis of large amounts of data of objective behavioral measurements, typically from smartphone sensors or social networking sites [210, 297, 182]. Especially the smartphone enables researchers to gain a deeper understanding of detailed objective measurements in relation to psychological traits like *personality* and *mood*. Defined as a field within psychoinformatics, *digital phenotyping* extends the concept of phenotypes as observable traits to digital traces of users [138, 18]. Typical outcomes of psychoinformatical research are a deeper understanding of latent constructs like personality or mental illnesses or just-in-time interventions [18]. The technical foundation of such research is *mobile (crowd)sensing*. *Mobile sensing* is the utilization of a mobile device – typically a smartphone – and its sensors for conducting and storing measurements. *Mobile crowdsensing* refers to the measurement of large-scale phenomena that cannot be measured by single devices [109, 156, 46]. Data is collected, shared – typically with a research institute – and information is extracted. In the context of psychoinformatics and personality-related research this

means, for example, crowdsourcing data from multiple users and gaining new insights in the relationship between smartphone data and user personality.

One of the key concepts in psychology in general and specifically in psychoinformatics / digital phenotyping, is *personality*. Personality relates to the behaviors, emotions, knowledge, and memory of a person [69] and shows that there are fundamental differences between people and how they experience behaviors and emotions. Vast literature of psychological research shows the connections between personality and a multitude of everyday aspects [220, 234, 150, 255, 134]. The field of *psychometrics* researches quantifiable measurements of psychological aspects. The most common tool to describe a person's personality in terms of specific traits is the Big Five model [192]. Standardized psychometric questionnaires yield concrete values for each of the traits, i.e., by filling out a questionnaire, the personality can be quantified on the five dimensions of the Big Five model. Those five dimensions are *openness to experience*, *conscientiousness*, *extraversion*, *agreeableness*, and *neuroticism*. Assessing a user's personality via a questionnaire then yields five values between 1 and 5, one for each of the traits.

Systematic technical measures for ensuring user privacy are a largely unaddressed aspect of psychoinformatics. When tracking data via mobile (crowd)sensing, deep insights about the user are possible, potentially risking his/her privacy, especially when dealing with psychological data. Depending on the region or specific use case of related apps in this field, certain privacy regulations have to be complied with. For example, the European Union implemented the General Data Protection Regulation (GDPR) in 2018 [233]. Deploying a psychoinformatical or a mobile crowdsensing app as a medical product needs certifications that might have additional specific requirements. Overall, when collecting mobile data, structured approaches in dealing with privacy have to be developed and implemented. However, in existing research, user privacy is often not considered at all [231] or no technical details are given [75, 45, 223, 52, 153, 120, 163, 305, 47, 195]. Furthermore, researchers conducting psychoinformatical studies face the problem that it is unclear to what extent demographics, education, and personality traits play a role when collecting data from users in daily life, which is crucial for study planning. While there is a variety of research on smartphone usage and personality traits [64, 75, 125, 127, 264, 263], there are still important knowledge gaps, for example

relating to the relationship between personality traits and the frequency of smartphone usage and usage session duration.

New knowledge about personality traits and smartphone usage helps deepen the understanding of human behavior. This, in turn, is crucial for psychological research, e.g., related to smartphone overuse [299, 161], and for a variety of fields in computer science and software development, especially when trying to understand a user base or tailoring services to customers' personalities. Mobile health (mHealth) applications benefit from personality information for the diagnosis or treatment of patients [229, 200, 310, 227, 123], e.g., giving individualized feedback for patients. In the field of recommender systems, understanding the user's personality helps in the calculation of recommendations and in understanding user behavior when interacting with recommendations [150, 24]. The importance of personality for the attitude toward advertising and mobile commerce is highlighted, for example, in [212, 306, 184]. Additionally, more knowledge about smartphone usage and personality traits serves as a vital building block toward the prediction of aspects of the user's personality without applying questionnaires [133].

1.2 Ubiquitous Social Networking

When looking into what people actually do with their smartphones, we observe a high focus on the interaction with other people by using messaging apps and social networking apps. Overall, 19.83% of time spent with the phone is spent on the messenger app WhatsApp alone, and 9.38% of time is spent on Facebook [207]. These two apps alone already account for almost a third of all smartphone usage. These observations reflect research describing social bonding as the "most crucial human motive" [248]. Psychological, as well as sociological research can help explain when and how social bonding works. Besides the already introduced concept of *personality*, two additional concepts are of importance here: *homophily* and *propinquity*. Not only is personality connected to everyday behavior but it also plays an integral part for social interactions and the forming of interpersonal relationships [50, 253]. *Homophily* describes the tendency of similar people to form meaningful bonds with each other. According to existing research, homophily structures any type of network [194]. *Propinquity* describes

how being in physical proximity often is a deciding factor for interpersonal attraction [183, 100]. These research results from psychology and social sciences indicate that *similarity* and *proximity* are deciding factors to be taken into account when developing social networking applications.

Applications that deal with the interactions between users in proximity lie at the intersection of *ubiquitous computing* and *social networking services*. Sometimes, this research field is also referred to as *proximity(-based) mobile social networks* [130]. The most common use case in this field is the recommendation of new contacts in proximity for the incentivization of social interaction. Psychological principles of what factors actually play a role for forming interpersonal bonds have rarely been considered. By integrating psychoinformatics with ubiquitous social networking, potentially more meaningful recommendations for new contacts can be given. Furthermore, most works rely on manually entered profile data like lists of interests [20, 296, 57, 269, 270, 211]. Such manual processes make it tedious for the user to use such systems, and constraints apply, for example, with respect to the often predefined lists of interests to choose from. With a higher degree of automation, inhibition thresholds for using such system are lowered, and services for individual users or groups of users can be provided seamlessly.

1.3 Research Objectives

The overall research goal of this thesis is related to the understanding and well-being of people. Psychoinformatical research related to personality traits and smartphone usage helps understand human behavior and can ultimately support the treatment of patients, understanding users of software systems, and tailoring individualized services. Ubiquitous social networking research serves as a tool for the incentivization of social interaction between people. In order to achieve this goal, first, in the field of psychoinformatics, we are researching the relationship between smartphone usage and the user's personality. Second, based on existing psychological research about the formation of interpersonal bonds, we research the implications this has for social networking applications, and develop prototypical concepts and applications incorporating our findings. Thus, for the integration of psychoinformatics with ubiquitous social networking, this thesis addresses two main research questions:

Research Question A What is the relationship between smartphone sensor and usage data and the user's personality?

Research Question B How to use insights from psychological research for the design of social networking applications?

The links between the two research questions are threefold: (a) on a conceptual level, we deal with the relationship between context data and psychological concepts like personality; (b) on a technical level, the collection of data, mobile sensing, serves as the basis; and (c) on a thematic level, privacy has to be a core focus when addressing either question.

In order to answer Research Question A, we pose the following research tasks:

A-Task1 *Survey related work in the field of psychoinformatics.*
Based on the initial outline in this section, we need to deepen what *personality* means, how it is assessed, and what the state of the art in psychoinformatical research is. This survey includes fundamentals of psychology, and it focuses on psychoinformatical studies dealing with smartphone data in relation to psychological concepts of the user.

A-Task2 *Develop an app for conducting psychoinformatical research that takes into account privacy awareness.*
In order to be able to analyze the relationship between smartphone data and personality, we need an app that allows for the related data collection. This task includes the design, implementation, and release of a mobile application that can be used for studies in the field of psychoinformatics. In order to be used for more research in the future, the app should provide objective measurements of any data that are potentially indicative of psychological traits of the user, i.e., all sensor data and usage statistics. Given the privacy concerns related to psychoinformatical or mobile crowdsensing apps, a structured approach to dealing with privacy has to be developed and implemented.

A-Task3 *Research what data users are willing to share with researchers and how the sharing of data relates to user characteristics and personality traits.*
This task relates to the improvement of study planning of future psychoinformatical

studies. The relationship between user characteristics like age, gender, education, and personality traits and the data users are willing to share in mobile crowdsensing studies should be analyzed.

A-Task4 *Research the relationship between smartphone usage frequency, usage session duration, and personality traits of the user.*
The app from A-Task2 should be used to collect data from users, capturing their smartphone usage behavior. Based on these data, a concrete study should analyze the relationship between smartphone usage and personality. This serves two purposes: first, to demonstrate the functionality of the results of the previous tasks; second, the new knowledge helps in future research in this field, for example, related to smartphone overuse or to the understanding of user behavior.

In order to answer Research Question B, we pose the following research tasks:

B-Task1 *Survey related work in the field of ubiquitous social networking.*
Terms and fundamentals about psychological concepts like homophily and propinquity need to be reviewed, and the related work in the field of ubiquitous social networking should be surveyed.

B-Task2 *Develop a concept for the incentivization of social interaction, incorporating findings from research in psychology and social sciences.*
One of the main themes in ubiquitous social networking is the incentivization of social interaction between strangers. When developing a concept for this, the findings surveyed in B-Task1 should be incorporated.

B-Task3 *Develop a concept to assess the similarity of users in ubiquitous social networking scenarios.*
Psychology and social sciences show that the key concept structuring social networks is homophily. This concept translates into the similarity of users in social networking services. The goal of this task is the assessment of the similarity of users of a ubiquitous social networking service. User similarity should be assessed in an automated way in order to lower the inhibition threshold for using systems implementing it.

B-Task4 *Develop example ubiquitous social networking applications taking into account the results of the previous tasks.*
Based on the findings from the previous tasks, example applications should be developed. The goal is to show the functionality and feasibility of our core idea of integrating research results from psychology and social sciences into the design of social networking applications.

1.4 Contributions

In the following, we summarize the main contributions of this thesis for both research questions.

1.4.1 Contributions Relating to Research Question A

With TYDR – Track Your Daily Routine – we present our app for psychoinformatical research. TYDR tracks more smartphone data than most existing tools. TYDR is a publicly available app and will serve as a tool in further research projects in the future. With PM-MoDaC, our privacy model for apps related to mobile data collection, to the best of our knowledge, we are the first to provide concrete measures that researchers and software developers can implement for the protection of their users' privacy in mobile crowdsensing apps. By analyzing user demographics and personality traits in relation to willingness to share data with researchers, we help researchers of future psychoinformatical studies in study planning. We analyzed the relationship between smartphone usage frequency and session duration and user demographics and personality traits. To the best of our knowledge, we are the first to look at these aspects specifically. The resulting new knowledge benefits psychologists and developers of mobile systems.

In the following four paragraphs, we will describe these four main contributions relating to Research Question A in more detail:

TYDR – App for Psychoinformatical Research. We developed, implemented, and evaluated a mobile system that enables the research of the relationship between smartphone sensor data and usage statistics and the users' personality. Our Android app TYDR tracks smartphone data and utilizes psychometric personality questionnaires.

With TYDR, we track a larger variety of smartphone data than most similar existing apps, including metadata on notifications, photos taken, and music played back by the user. We optimized the tracking of sensor data by assessing the trade-off of the size of data and battery consumption and granularity of the stored information. Our user interface is designed to incentivize users to install the app and fill out questionnaires. TYDR processes and visualizes the tracked sensor and usage data as well as the results of the personality questionnaires. The ethics commissions of Technische Universität Berlin approved the use of TYDR for our psychoinformatical studies. We released TYDR on Google Play in October 2018 and registered 3,921 installations since then. TYDR is planned to be used in future projects in Germany and Austria for further psychoinformatical studies with thousands of users.

Privacy Model for Mobile Data Collection Apps. Surveying the related psychoinformatical work, we saw a lack of a consistent approach to privacy awareness for apps relating to the mobile collection of data. To the best of our knowledge, we are the first to propose a full-scale, integrated privacy model. Our privacy model called PM-MoDaC consists of nine concrete measures to be taken to ensure the participants'/users' privacy. These measures include transparently informing the users about the data being collected, the anonymization of user data, and enabling an opt-out option. As part of our privacy model, we present a process for anonymized data storing while still being able to identify individual users who successfully completed a psychological study with the app. We present the implementation of all our privacy measures in TYDR. Our privacy model PM-MoDaC has already started to gain visibility, and other researchers started utilizing our approach for their research (e.g., [127]).

Analysis of Users' Willingness to Share Data with Researchers. We collected data with TYDR over the course of a 2-months period and extensively evaluated our privacy model and which data users are willing to share. We found evidence that our users accept our proposed privacy model. Based on the data about granting TYDR all or no Android system permissions, we found evidence that younger users tend to be less willing to share their data (average age of 30 years compared to 35 years). We also observed that female users tend to be less willing to share data compared to male users.

We did not find any evidence that education or personality traits are a factor related to data sharing. TYDR users score higher on the personality trait *openness to experience* than the average of the population, which we assume to be evidence that the type of app influences the user base it attracts in terms of average personality traits. We believe that our findings can help other researchers conducting similar research estimate the data to be expected.

Smartphone Usage Frequency and Usage Session Duration in Relation to Personality Traits. We conducted a psychoinformatical study and investigated associations between personality traits and smartphone usage in daily life. Based on 11 months of data collection with TYDR, we analyzed 526 participants (mean age 34.57 years, SD = 12.85, 21% female) who provided data for 48 days, on average (SD = 63.2, range 2 to 304). We measured the Big Five personality traits (openness, conscientiousness, extraversion, agreeableness, neuroticism). Using hierarchical linear models, we analyzed associations between personality traits and (1) number of screen wakeups and (2) average session duration. On average, our users used their smartphone 72 times per day, for 3.7 minutes each time on average. We found that participants reached for their smartphone more frequently during weekdays with a shorter duration of usage compared to weekends. Younger people used their smartphones more often but with a shorter duration than older people. Female participants spent more time using smartphones per session than male participants. Extraversion and neuroticism were associated with more frequent usage of the smartphone per day while conscientiousness was associated with a shorter mean session duration. Our results are helpful for the assessment and treatment of patients, for example, related to smartphone overuse. Additionally, our results help developers of mobile systems individualize services and understand their users' behavior.

1.4.2 Contributions Relating to Research Question B

With SimCon, we present a concept for the smartphone-mediated incentivization of social interaction between strangers. The concept is based on mobile sensing and can be implemented in a completely unobtrusive way without any necessary user interaction. To the best of our knowledge, we are the first to explicitly consider psychological research

results in such a concept, as well as the first to base the concept on mobile sensing, enabling full automation and thus lowering the inhibition threshold for usage. SimCon is based on the similarity of users. We introduce metrics for similarity estimation in ubiquitous social networking scenarios utilizing device-to-device communication and probabilistic data structures. The most important metric we introduce is CBF-Dice, which is generalizable for the fast and space-efficient similarity estimation of any two multisets. With MobRec and GroupMusic, we present two highly automated example applications for ubiquitous social networks. MobRec is a platform for recommender systems that does not exhibit the typical lock-in effects of such systems. For MobRec, we implemented and evaluated unobtrusive device-to-device data exchange running in the background on off-the-shelf iOS and Android devices. GroupMusic is a group recommender system that plays back music according to the taste of currently present users. The architecture and example applications can serve as blueprints or best practices for researchers and developers in the fields of device-to-device computing, mobile software engineering, and recommender systems.

In the following four paragraphs, we will describe these four main contributions relating to Research Question B in more detail:

Concept for Contact Recommendations: SimCon. While existing social networking services tend to connect people who know each other, people show a desire to also connect to yet unknown people in physical proximity. This is reflected in the fact that the most prevalent topic in the field of ubiquitous social networking is the incentivization of social interaction between strangers. Based on the concepts of personality, homophily, and propinquity, we designed a concept for contact recommendations. The idea is that the context data on the phone reflects personality as well as preferences, for example, with respect to visited locations, media played back, or structuring of daily life. Thus, similar context data implies similar personality and preferences. Our concept SimCon proposes to exchange such context data in a device-to-device manner and to calculate the similarity of the exchanged data in order to recommend similar users in proximity. SimCon is based on mobile sensing, so no data has to be entered manually by the user. The whole contact recommendation process

can run fully automatically, lowering the inhibition threshold, and potentially providing more meaningful recommendations.

Metrics for Similarity Estimation of Multisets. Building on the previous main contribution, we proposed, developed, and evaluated metrics for estimating the similarity between two smartphone users in ubiquitous social networking settings. Our approach is generalizable for any other similarity estimation of frequencies represented as multisets. We developed our solution based on the example of similarity in musical taste. We showed that a single exchange of a probabilistic data structure between two devices can closely estimate the similarity of two users – without the need to contact a third-party server. We introduce metrics for fast and space-efficient approximation of the Dice coefficient of two multisets – based on the comparison of two Counting Bloom Filters or two Count-Min Sketches. Our analysis shows that utilizing a single hash function minimizes the error when comparing these probabilistic data structures. The size that should be chosen for the data structure depends on the expected average number of unique input elements. In an experimental study, using real user data, we showed that a Counting Bloom Filter with a single hash function and a small length – twice the size of average number of unique input elements – is sufficient to accurately estimate the similarity between two multisets representing the musical tastes of two users.

Mobile Platform for Decentralized Recommender Systems: MobRec. As an example application for ubiquitous social networking services, we developed a mobile platform for decentralized recommender systems. The core concept is that everything runs on smartphones. Ratings and preferences are captured locally. During daily life, these ratings and preferences are exchanged with users in proximity in a device-to-device manner. Locally running recommender systems or third-party service providers can then recommend items based on own data and data received from users met before. We implemented the platform for off-the-shelf smartphones for both Android and iOS. We implemented device-to-device data exchange that can run in the background on both platforms. In our evaluation, we showed the feasibility of our approach. Our implementation can serve as a blueprint for future research and software development in this field.

Group Music Recommender System: GroupMusic. We developed another example application for ubiquitous social networking services, for groups of users. We created the system GroupMusic that allows the generation and playback of group music playlists that are based on the musical taste of individual guests attending a meeting. In our architecture, we utilize automatically collected data on smartphones for the automatized generation of group music playlists. We follow the idea of utilizing context data in a preprocessing step to generate a group music profile for the recommendation process that generates a group music playlist. The whole process is almost fully automated and the played back music automatically adapts to the users currently present. This contribution is especially relevant for researchers and developers of ubiquitous computing systems.

1.5 Outline

Reflecting the two overall research questions addressed, this thesis is divided into two main parts, each dealing with one of the research questions A and B.

Part I focuses on deepening the scientific understanding of people and their behavior and addresses research question A (*What is the relationship between smartphone sensor and usage data and the user's personality?*). We start by surveying related psychoinformatical work in Chapter 3 (A-Task1). We introduce our mobile system TYDR, which enables the research of the relationship between smartphone sensor data and usage statistics and the users' personality (A-Task2) in Chapter 4. This includes our privacy model PM-MoDaC and data analysis regarding what data users are willing to share with researchers in mobile crowdsensing scenarios (A-Task3). Based on data we collected in a study conducted with TYDR, we analyze smartphone usage frequency and duration in relation with personality traits in Chapter 5 (A-Task4).

Part II focuses on offering services based on psychological principles of social behavior. Here, we address research question B (*How to use insights from psychological research for the design of social networking applications?*). Addressing B-Task1 in Chapter 8, we extensively survey related work. Based on our findings, we develop a concept for the incentivization of social interaction called SimCon in Chapter 9 (B-Task2). Building on these results, we propose, develop, and evaluate metrics for

estimating the similarity of two users in Chapter 10 (B-Task3). Chapters 11 and 12 serve as examples for ubiquitous social networking applications that we developed based on our previous results (B-Task4). In Chapter 11, we present our mobile platform for decentralized recommender systems MobRec. In Chapter 12, we present an example application GroupMusic for groups of users that plays back music according to the taste of users currently present.

In Chapter 14, we summarize our findings, and Chapter 15 gives an outlook for further research.

1.6 Publications

Parts of this thesis have previously been published in the following 11 papers. One received a best paper award, and one a best paper runner-up award.

- F. Beierle, S. Göndör, and A. Küpper. "Towards a Three-Tiered Social Graph in Decentralized Online Social Networks". In: *Proc. 7th International Workshop on Hot Topics in Planet-Scale mObile Computing and Online Social neTworking (HotPOST)*. ACM, June 2015, pp. 1–6. DOI: 10.1145/2757513.2757517 [31] [**Best Paper Runner-up**]

- F. Beierle, K. Grunert, S. Göndör, and A. Küpper. "Privacy-Aware Social Music Playlist Generation". In: *Proc. 2016 IEEE International Conference on Communications (ICC)*. IEEE, 2016, pp. 5650–5656. DOI: 10.1109/ICC.2016.7511602 [32]

- F. Beierle, K. Grunert, S. Göndör, and V. Schlüter. "Towards Psychometrics-Based Friend Recommendations in Social Networking Services". In: *2017 IEEE International Conference on AI & Mobile Services (AIMS)*. IEEE, June 2017, pp. 105–108. DOI: 10.1109/AIMS.2017.22 [33]

- F. Beierle, V. T. Tran, M. Allemand, P. Neff, W. Schlee, T. Probst, R. Pryss, and J. Zimmermann. "TYDR – Track Your Daily Routine. Android App for Tracking Smartphone Sensor and Usage Data". In: *2018 IEEE/ACM 5th International*

Conference on Mobile Software Engineering and Systems (MOBILESoft). ACM, 2018, pp. 72–75. DOI: 10.1145/3197231.3197235 [38]

- F. Beierle. "Do You Like What I Like? Similarity Estimation in Proximity-Based Mobile Social Networks". In: *2018 17th IEEE International Conference On Trust, Security And Privacy In Computing And Communications (TrustCom)*. IEEE, Aug. 2018, pp. 1040–1047. DOI: 10.1109/TrustCom/BigDataSE.2018.00146 [26]

- F. Beierle, V. T. Tran, M. Allemand, P. Neff, W. Schlee, T. Probst, R. Pryss, and J. Zimmermann. "Context Data Categories and Privacy Model for Mobile Data Collection Apps". In: *Procedia Computer Science*. The 15th International Conference on Mobile Systems and Pervasive Computing (MobiSPC) 134 (2018), pp. 18–25. DOI: 10.1016/j.procs.2018.07.139 [37] [**Best Paper**]

- F. Beierle and T. Eichinger. "Collaborating with Users in Proximity for Decentralized Mobile Recommender Systems". In: *Proc. IEEE 16th International Conference on Ubiquitous Intelligence and Computing (UIC)*. IEEE, June 2019, pp. 1192–1197. DOI: 10.1109/SmartWorld-UIC-ATC-SCALCOM-IOP-SCI.2019.00222 [30]

- T. Eichinger, F. Beierle, R. Papke, L. Rebscher, H. C. Tran, and M. Trzeciak. "On Gossip-Based Information Dissemination in Pervasive Recommender Systems". In: *Prod. 13th ACM Conference on Recommender Systems (RecSys)*. ACM, Sept. 2019, pp. 442–446. DOI: 10.1145/3298689.3347067 [90]

- F. Beierle, V. T. Tran, M. Allemand, P. Neff, W. Schlee, T. Probst, J. Zimmermann, and R. Pryss. "What Data Are Smartphone Users Willing to Share with Researchers?" In: *Journal of Ambient Intelligence and Humanized Computing* 11 (2020), pp. 2277–2289. DOI: 10.1007/s12652-019-01355-6 [39]

- F. Beierle, T. Probst, M. Allemand, J. Zimmermann, R. Pryss, P. Neff, W. Schlee, S. Stieger, and S. Budimir. "Frequency and Duration of Daily Smartphone Usage in Relation to Personality Traits". In: *Digital Psychology* 1.1 (2020), pp. 20–28. DOI: 10.24989/dp.v1i1.1821 [35]

- F. Beierle and S. Egger. "MobRec – Mobile Platform for Decentralized Recommender Systems". In: *IEEE Access* 8 (2020), pp. 185311–185329. DOI: 10.1109/ACCESS.2020.3029319 [29]

Some parts of this thesis are appearing in the following book chapter:

- F. Beierle, S. C. Matz, and M. Allemand. "Smartphone Sensing in Personality Science". In: *Mobile Sensing in Psychology: Methods and Applications*. Ed. by M. R. Mehl, C. Wrzus, M. Eid, G. Harari, and U. E. Priemer. New York City, NY, USA: Guilford Press, 2021 (to appear) [34]

While I was working on this thesis, I also contributed to 17 additional publications which are only loosely related to this thesis. Two publications are related to attribute-based encryption in mobile scenarios [307, 76]. Three publications are related to the global reachability of users registered with different communication service providers. We utilized a decentralized directory supporting the storing of global reachability information [140, 104, 141]. In [113, 114, 115], we followed a similar approach. Here, we proposed solutions for a federation of online social networking services – including a decentralized global reachability registry and mechanisms for the migration of user profiles to different service providers. In the field of recommender systems, we built and evaluated a system for conference recommendations based on different relations between authors [36]. The publications [27] and [28] deal with the psychological concept of *choice overload* or *overchoice*, the tendency of people to not make any decision when faced with too many options. We analyzed this effect in related-article recommendations in digital libraries. In [89], we developed a method to calculate a latent similarity of two users based on their texting data. This is related to B-Task3 (*Develop a concept to assess the similarity of users in ubiquitous social networking scenarios.*). Additional publications are related to software architectures for data analysis [309, 80, 81] and to blockchain [176, 177]:

- S. Zickau, F. Beierle, and I. Denisow. "Securing Mobile Cloud Data with Personalized Attribute-Based Meta Information". In: *Proc. 3rd IEEE International Conference on Mobile Cloud Computing, Services, and Engineering*

(MobileCloud). IEEE, Mar. 2015, pp. 205–210. DOI: 10.1109/MobileCloud.2015.14 [307]

- I. Denisow, S. Zickau, F. Beierle, and A. Küpper. "Dynamic Location Information in Attribute-Based Encryption Schemes". In: *Proc. 9th International Conference on Next Generation Mobile Applications, Services and Technologies (NGMAST)*. IEEE, 2015, pp. 240–247. DOI: 10.1109/NGMAST.2015.63 [76]

- I. T. Javed, R. Copeland, N. Crespi, F. Beierle, S. Göndör, A. Küpper, M. Emmelmann, A. Corici, K. Corre, J.-M. Crom, A. Bouabdallah, F. Oberle, I. Friese, A. Caldeira, G. Dias, R. Chaves, and N. Santo. "Global Identity and Reachability Framework for Interoperable P2P Communication Services". In: *Proc. 2016 Conference on Innovations in Clouds, Internet and Networks (ICIN)*. IFIP, 2016, pp. 59–66 [140]

- I. Friese, R. Copeland, S. Göndör, F. Beierle, A. Küpper, R. L. Pereira, and J.-M. Crom. "Cross-Domain Discovery of Communication Peers: Identity Mapping and Discovery Services (IMaDS)". in: *Proc. 2017 European Conference on Networks and Communications (EuCNC)*. IEEE, June 2017, pp. 1–6. DOI: 10.1109/EuCNC.2017.7980642 [104]

- I. T. Javed, R. Copeland, N. Crespi, M. Emmelmann, A. Corici, A. Bouabdallah, T. Zhang, S. El Jaouhari, F. Beierle, S. Göndör, A. Küpper, K. Corre, J.-M. Crom, F. Oberle, I. Friese, A. Caldeira, G. Dias, N. Santos, R. Chaves, and R. L. Pereira. "Cross-Domain Identity and Discovery Framework for Web Calling Services". In: *Annals of Telecommunications* 72.7 (Aug. 2017), pp. 459–468. DOI: 10.1007/s12243-017-0587-2 [141]

- S. Göndör, F. Beierle, E. Kücükbayraktar, H. Hebbo, S. Sharhan, and A. Küpper. "Towards Migration of User Profiles in the SONIC Online Social Network Federation". In: *Proc. International Multi-Conference on Computing in the Global Information Technology (ICCGI)*. IARIA, 2015, pp. 1–5 [113]

- S. Göndör, F. Beierle, S. Sharhan, H. Hebbo, E. Kücükbayraktar, and A. Küpper. "SONIC: Bridging the Gap between Different Online Social Network

Platforms". In: *Proc. 2015 IEEE International Conference on Smart City/SocialCom/SustainCom (SmartCity)*. IEEE, Dec. 2015, pp. 399–406. DOI: 10.1109/SmartCity.2015.104 [114]

- S. Göndör, F. Beierle, S. Sharhan, and A. Küpper. "Distributed and Domain-Independent Identity Management for User Profiles in the SONIC Online Social Network Federation". In: *International Conference on Computational Social Networks (CSoNet)*. Ed. by H. T. Nguyen and V. Snasel. Vol. 9795. LNCS. Springer, 2016, pp. 226–238. DOI: 10.1007/978-3-319-42345-6_20 [115]

- F. Beierle, J. Tan, and K. Grunert. "Analyzing Social Relations for Recommending Academic Conferences". In: *Proc. 8th ACM International Workshop on Hot Topics in Planet-Scale mObile Computing and Online Social neTworking (HotPOST)*. ACM, 2016, pp. 37–42. DOI: 10.1145/2944789.2944871 [36]

- F. Beierle, A. Aizawa, and J. Beel. "Exploring Choice Overload in Related-Article Recommendations in Digital Libraries". In: *Proc. 5th International Workshop on Bibliometric-Enhanced Information Retrieval (BIR)*. vol. 1823. CEUR Workshop Proceedings. CEUR-WS, 2017, pp. 51–61 [27]

- T. Eichinger, F. Beierle, S. U. Khan, R. Middelanis, S. Veeraraghavan, and S. Tabibzadeh. "Affinity: A System for Latent User Similarity Comparison on Texting Data". In: *Proc. 2019 IEEE International Conference on Communications (ICC)*. IEEE, May 2019, pp. 1–7. DOI: 10.1109/ICC.2019.8761051 [89]

- E. Zielinski, J. Schulz-Zander, M. Zimmermann, C. Schellenberger, A. Ramirez, F. Zeiger, M. Mormul, F. Hetzelt, F. Beierle, H. Klaus, H. Ruckstuhl, and A. Artemenko. "Secure Real-Time Communication and Computing Infrastructure for Industry 4.0 — Challenges and Opportunities". In: *Proc. 2019 International Conference on Networked Systems (NetSys)*. IEEE, Mar. 2019, pp. 1–6. DOI: 10.1109/NetSys.2019.8854499 [309]

- H. Dinh-Tuan, F. Beierle, and S. Rodriguez Garzon. "MAIA: A Microservices-Based Architecture for Industrial Data Analytics". In: *Proc. 2019*

IEEE International Conference on Industrial Cyber Physical Systems (ICPS). IEEE, May 2019, pp. 23–30. DOI: 10.1109/ICPHYS.2019.8780345 [80]

- Z. A. Lux, F. Beierle, S. Zickau, and S. Göndör. "Full-Text Search for Verifiable Credential Metadata on Distributed Ledgers". In: *Proc. 2019 Sixth International Conference on Internet of Things: Systems, Management and Security (IOTSMS)*. IEEE, Oct. 2019, pp. 519–528. DOI: 10.1109/IOTSMS48152.2019.8939249 [176]

- F. Beierle, A. Aizawa, A. Collins, and J. Beel. "Choice Overload and Recommendation Effectiveness in Related-Article Recommendations". In: *International Journal on Digital Libraries* 21.3 (Sept. 2020), pp. 231–246. DOI: 10.1007/s00799-019-00270-7 [28]

- Z. A. Lux, D. Thatmann, S. Zickau, and F. Beierle. "Distributed-Ledger-Based Authentication with Decentralized Identifiers and Verifiable Credentials". In: *2020 2nd Conference on Blockchain Research Applications for Innovative Networks and Services (BRAINS)*. IEEE, Sept. 2020, pp. 71–78. DOI: 10.1109/BRAINS49436.2020.9223292 [177]

- H. Dinh-Tuan, M. Mora-Martinez, F. Beierle, and S. Rodriguez Garzon. "Development Frameworks for Microservice-based Applications: Evaluation and Comparison". In: *Proc. 2020 European Symposium on Software Engineering (ESSE)*. ACM, Nov. 2020, pp. 12–20. DOI: 10.1145/3393822.3432339 (in print) [81]

Part I

Mobile Sensing and Personality

2 Overview

Abstract This chapter gives a brief overview about how the following chapters will answer the research question *What is the relationship between smartphone sensor and usage data and the user's personality?*

3 Related Work

Abstract This chapter gives an extensive overview about related work in the field of psychoinformatics. We give an overview about the related terms, showing the importance of the psychological concept of *personality*. Next, we give a brief summary about the fundamentals of *context data*. We then survey previous work and studies related to psychoinformatical research utilizing mobile crowdsensing. An extensive overview about related studies summarizes the state-of-the-art.

4 TYDR: Track Your Daily Routine

Abstract This chapter introduces TYDR – Track Your Daily Routine, an Android app that enables the research of the relationship between smartphone sensor data and usage statistics and the users' personality via mobile crowdsensing. TYDR processes and visualizes the tracked data as well as the results of the personality questionnaires. We released TYDR on Google Play in October 2018 and registered 3,921 installations since then. To the best of our knowledge, we are the first to propose a full-scale, integrated privacy model specifically for apps related to mobile collection of data. Our privacy model called PM-MoDaC (Privacy Model for Mobile Data Collection Apps) consists of nine concrete measures to be taken to ensure the users' privacy. These measures include transparently informing the users about the data being collected, the anonymization of user data, and enabling an opt-out option. We present the implementation of all the privacy measures in TYDR. We collected data with TYDR over the course of a two-months period and extensively evaluated our privacy model and which data users are willing to share. Based on data about granting TYDR all or no Android system permissions, we found evidence that younger users tend to be less willing to share their data (average age of 30 years compared to 35 years). We also observed that female users tend to be less willing to share data compared to male users. We did not find any evidence that education or personality traits are a factor related to data sharing. TYDR users score higher on the personality trait *openness to experience* than the average of the population, which we assume to be evidence that the type of app influences the user base it attracts in terms of average personality traits.

5 Smartphone Usage Frequency and Duration in Relation to Personality Traits

Abstract This chapter reports about our psychoinformatical study investigating associations between personality traits and smartphone usage in daily life. Based on 11 months of data collection with TYDR, we analyzed 526 participants (mean age 34.57 years, SD = 12.85, 21% female) who provided data for 48 days, on average (SD = 63.2, range 2 to 304). We measured the Big Five personality traits (openness, conscientiousness, extraversion, agreeableness, neuroticism). Using hierarchical linear models, we analyzed associations between personality traits and (1) number of screen wakeups and (2) average session duration. On average, our users used their smartphone 72 times per day, for 3.7 minutes each time on average. We found that participants reached for their smartphone more frequently during weekdays with a shorter duration of usage compared to weekends. Younger people used their smartphones more often but with a shorter duration than older people. Female participants spent more time using smartphones per session than male participants. Extraversion and neuroticism were associated with more frequent usage of the smartphone per day while conscientiousness was associated with shorter mean session duration. Our results are helpful for the assessment and treatment of patients, for example, related to smartphone overuse. Additionally, our results can help developers of mobile systems to individualize services and to understand their users' behavior.

6 Interim Conclusions for Part I: Privacy-aware Mobile Sensing in Psychoinformatics

Abstract This chapter gives a brief summary about the first part of the thesis and transitions to the second part of the thesis.

Part II

Mobile Sensing in Ubiquitous Social Networking

7 Overview

Abstract This chapter gives a brief overview about how the following chapters will answer the research question *How to use insights from psychological research for the design of social networking applications?*

8 Related Work

Abstract This chapter gives an extensive overview about related work in the field of ubiquitous social networking. We start with presenting the fundamentals about related concepts from psychology and social sciences. The key finding is that similarity is the key feature structuring social networks. Then, the chapter gives details about relevant papers of the last 15 years, highlighting the research questions addressed and topics covered. One of the most common use case scenarios is the incentivization of social interaction. On a technical level, common themes are software architectures and device-to-device communication.

9 SimCon: A Concept for Contact Recommendations

Abstract In this chapter, we present our concept for recommending similar people in physical proximity – SimCon. While existing social networking services tend to connect people who already know each other, people show a desire to also connect to yet unknown people in physical proximity. This is reflected in the fact that the most prevalent topic in the field of ubiquitous social networking is the incentivization of social interaction between strangers. Based on the concepts of personality, homophily, and propinquity, we design a concept for contact recommendations. The idea is that the context data on the phone reflect personality as well as preferences, for example with respect to visited locations, media played back, or structuring of daily life. Thus, similar context data imply similar personality and preferences. Our concept SimCon proposes to exchange such context data in a device-to-device manner and to calculate the similarity of the exchanged data in order to recommend similar users in proximity. SimCon is based on mobile sensing, so – in contrast to existing approaches – no data has to be entered manually by the user. The whole contact recommendation process can run fully automatically, lowering the inhibition threshold, and potentially providing more meaningful recommendations.

10 Similarity Estimation

Abstract In this chapter, we propose, develop, and evaluate metrics for estimating the similarity between two smartphone users in ubiquitous social networking settings. Our approach is generalizable for any other similarity estimation of frequencies represented as multisets. We develop our solution based on the example of similarity in musical taste. We show that a single exchange of a probabilistic data structure between two devices can closely estimate the similarity of two users – without the need to contact a third-party server. We introduce metrics for fast and space-efficient approximation of the Dice coefficient of two multisets – based on the comparison of two Counting Bloom Filters or two Count-Min Sketches. Our analysis shows that utilizing a single hash function minimizes the error when comparing these probabilistic data structures. The size that should be chosen for the data structure depends on the expected average number of unique input elements. In an experimental study, using real user data, we show that a Counting Bloom Filter with a single hash function and a small length – twice the size of average number of unique input elements – is sufficient to accurately estimate the similarity between two multisets representing the musical tastes of two users.

11 MobRec: Mobile Platform for Decentralized Recommender Systems

Abstract In this chapter, we develop a mobile platform for decentralized recommender systems – MobRec. The core concept is that everything runs on smartphones. Due to decentralization, MobRec does not exhibit the lock-in effects present in centralized service providers for recommender systems. In MobRec, ratings and preferences are captured locally. During daily life, these ratings and preferences are exchanged with users in proximity in a device-to-device manner. Locally running recommender systems or third-party service providers can then recommend items based on own data and data received from users met before. We implement the platform for off-the-shelf smartphones for both Android and iOS. We implement device-to-device data exchange that can run in the background on both platforms. In our evaluation, we show the feasibility of our approach. Our implementation can serve as a blueprint for future research and software development in this field.

12 GroupMusic: Recommender System for Groups

Abstract In this chapter, we present the system GroupMusic that allows the generation and playback of group music playlists that are based on the musical taste of individual guests attending a meeting. In our architecture, we use mobile sensing to unobtrusively collect musical taste on smartphones for the automatized generation of group music playlists. We follow the idea of utilizing context data in a preprocessing step to generate a group music profile for the recommendation process that generates a group music playlist. The whole process is almost fully automated and the played back music automatically adapts to the users currently present. The results are relevant for researchers and developers in the fields of ubiquitous systems and group recommender systems.

13 Interim Conclusions for Part II: Advancing Ubiquitous Social Networking Through Mobile Sensing

Abstract This chapter briefly summarizes the second part of the thesis, Chapters 7 through 12.

Part III

Conclusions and Outlook

14 Conclusions

Abstract The conclusion summarizes the results of the book.

15 Outlook

Abstract The outlook outlines future work in several different directions.

List of Figures

List of Tables

Bibliography

[1] M. Ahmed, Y. Li, M. Waqas, M. Sheraz, D. Jin, and Z. Han. "A Survey on Socially Aware Device-to-Device Communications". In: *IEEE Communications Surveys Tutorials* 20.3 (2018), pp. 2169–2197. DOI: 10.1109/COMST.2018.2820069.

[2] A. Al-Akkad, C. Raffelsberger, A. Boden, L. Ramirez, and A. Zimmermann. "Tweeting 'When Online Is off'? Opportunistically Creating Mobile Ad-Hoc Networks in Response to Disrupted Infrastructure". In: *ISCRAM*. 2014.

[3] M. Alaggan, S. Gambs, and A.-M. Kermarrec. "BLIP: Non-Interactive Differentially-Private Similarity Computation on Bloom Filters". In: *Stabilization, Safety, and Security of Distributed Systems*. Ed. by A. W. Richa and C. Scheideler. Lecture Notes in Computer Science 7596. Springer Berlin Heidelberg, 2012, pp. 202–216.

[4] I. Andone, K. Błaszkiewicz, M. Eibes, B. Trendafilov, C. Montag, and A. Markowetz. "How Age and Gender Affect Smartphone Usage". In: *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct*. UbiComp '16. ACM, 2016, pp. 9–12. DOI: 10.1145/2968219.2971451.

[5] I. Andone, K. B\laszkiewicz, M. Eibes, B. Trendafilov, C. Montag, and A. Markowetz. "Menthal: A Framework for Mobile Data Collection and Analysis". In: *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct*. UbiComp '16. ACM, 2016, pp. 624–629. DOI: 10.1145/2968219.2971591.

[6] I. Andone, K. Blaszkiewicz, M. Eibes, B. Trendafilov, C. Montag, and A. Markowetz. "Menthal: Quantifying Smartphone Usage". In: *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous*

Computing: Adjunct. UbiComp '16. ACM, 2016, pp. 559–564. DOI: 10.1145/2968219.2968321.

[7] N. Aneja and S. Gambhir. *Profile-Based Ad Hoc Social Networking Using Wi-Fi Direct on the Top of Android*. Research Article. 2018. DOI: 10.1155/2018/9469536.

[8] N. Y. Asabere, A. Acakpovi, and M. B. Michael. "Improving Socially-Aware Recommendation Accuracy Through Personality". In: *IEEE Transactions on Affective Computing* 9.3 (July 2018), pp. 351–361. DOI: 10.1109/TAFFC.2017.2695605.

[9] J. Asselbergs, J. Ruwaard, M. Ejdys, N. Schrader, M. Sijbrandij, and H. Riper. "Mobile Phone-Based Unobtrusive Ecological Momentary Assessment of Day-to-Day Mood: An Explorative Study". In: *Journal of Medical Internet Research* 18.3 (Mar. 2016), e72. DOI: 10.2196/jmir.5505.

[10] M. Atzmueller, M. Becker, M. Kibanov, C. Scholz, S. Doerfel, A. Hotho, B.-E. Macek, F. Mitzlaff, J. Mueller, and G. Stumme. "Ubicon and Its Applications for Ubiquitous Social Computing". In: *New Review of Hypermedia and Multimedia* 20.1 (Jan. 2014), pp. 53–77. DOI: 10.1080/13614568.2013.873488.

[11] D. Azucar, D. Marengo, and M. Settanni. "Predicting the Big 5 Personality Traits from Digital Footprints on Social Media: A Meta-Analysis". In: *Personality and Individual Differences* 124 (Apr. 2018), pp. 150–159. DOI: 10.1016/j.paid.2017.12.018.

[12] M. D. Back, J. M. Stopfer, S. Vazire, S. Gaddis, S. C. Schmukle, B. Egloff, and S. D. Gosling. "Facebook Profiles Reflect Actual Personality, Not Self-Idealization". In: *Psychological Science* 21.3 (Jan. 2010), pp. 372–374. DOI: 10.1177/0956797609360756.

[13] L. Baltrunas, L. Rokach, M. Kaminskas, B. Shapira, F. Ricci, and K.-h. Luke. "Best Usage Context Prediction for Music Tracks". In: *In Proceedings of the 2nd Workshop on Context Aware Recommender Systems*. 2010.

[14] J. Bao, Y. Zheng, D. Wilkie, and M. Mokbel. "Recommendations in Location-Based Social Networks: A Survey". In: *Geoinformatica* 19.3 (2015), pp. 525–565. DOI: 10.1007/s10707-014-0220-8.

[15] R. Baraglia, P. Dazzi, M. Mordacchini, and L. Ricci. "A Peer-to-Peer Recommender System for Self-Emerging User Communities Based on Gossip Overlays". In: *Journal of Computer and System Sciences*. 10th IEEE International Conference on Computer and Information Technology, 2010 79.2 (Mar. 2013), pp. 291–308. DOI: 10.1016/j.jcss.2012.05.011.

[16] L. N. Barbosa, J. Gemmell, M. Horvath, and T. Heimfarth. "Distributed User-Based Collaborative Filtering on an Opportunistic Network". In: *2018 IEEE 32nd International Conference on Advanced Information Networking and Applications (AINA)*. May 2018, pp. 266–273. DOI: 10.1109/AINA.2018.00049.

[17] D. Bates, M. Mächler, B. Bolker, and S. Walker. "Fitting Linear Mixed-Effects Models Using Lme4". In: *Journal of Statistical Software* 67.1 (Oct. 2015), pp. 1–48. DOI: 10.18637/jss.v067.i01.

[18] H. Baumeister and C. Montag, eds. *Digital Phenotyping and Mobile Sensing: New Developments in Psychoinformatics*. Studies in Neuroscience, Psychology and Behavioral Economics. Springer International Publishing, 2019. DOI: 10.1007/978-3-030-31620-4.

[19] R. F. Baumeister, K. D. Vohs, and D. C. Funder. "Psychology as the Science of Self-Reports and Finger Movements: Whatever Happened to Actual Behavior?" In: *Perspectives on Psychological Science* 2.4 (Dec. 2007), pp. 396–403. DOI: 10.1111/j.1745-6916.2007.00051.x.

[20] A. Beach, M. Gartrell, S. Akkala, J. Elston, J. Kelley, K. Nishimoto, B. Ray, S. Razgulin, K. Sundaresan, B. Surendar, M. Terada, and R. Han. "WhozThat? Evolving an Ecosystem for Context-Aware Mobile Social Networks". In: *IEEE Network* 22.4 (2008), pp. 50–55.

[21] A. Beach, M. Gartrell, X. Xing, and R. Han. "SocialFusion: Context-Aware Inference and Recommendation By Fusing Mobile, Sensor, and Social Data; CU-CS-1059-09". In: (2009).

[22] A. Beach, M. Gartrell, X. Xing, R. Han, Q. Lv, S. Mishra, and K. Seada. "Fusing Mobile, Sensor, and Social Data to Fully Enable Context-Aware Computing". In: *Proceedings of the Eleventh Workshop on Mobile Computing Systems & Applications*. ACM, 2010, pp. 60–65.

[23] D. Becker, V. Bremer, B. Funk, J. Asselbergs, H. Riper, and J. Ruwaard. "How to Predict Mood? Delving into Features of Smartphone-Based Data". In: *Twenty-second Americas Conference on Information Systems (AMCIS)* (Aug. 2016), pp. 1–10.

[24] J. Beel, C. Breitinger, S. Langer, A. Lommatzsch, and B. Gipp. "Towards Reproducibility in Recommender-Systems Research". In: *User Modeling and User-Adapted Interaction* 26.1 (Mar. 2016), pp. 69–101. DOI: 10.1007/s11257-016-9174-x.

[25] J. Beel, S. Langer, A. Nürnberger, and M. Genzmehr. "The Impact of Demographics (Age and Gender) and Other User-Characteristics on Evaluating Recommender Systems". In: *Research and Advanced Technology for Digital Libraries (TPDL 2013)*. Ed. by T. Aalberg, C. Papatheodorou, M. Dobreva, G. Tsakonas, and C. J. Farrugia. Vol. 8092. LNCS. Springer, 2013, pp. 396–400. DOI: 10.1007/978-3-642-40501-3_45.

[26] F. Beierle. "Do You Like What I Like? Similarity Estimation in Proximity-Based Mobile Social Networks". In: *2018 17th IEEE International Conference On Trust, Security And Privacy In Computing And Communications (TrustCom)*. IEEE, Aug. 2018, pp. 1040–1047. DOI: 10.1109/TrustCom/BigDataSE.2018.00146.

[27] F. Beierle, A. Aizawa, and J. Beel. "Exploring Choice Overload in Related-Article Recommendations in Digital Libraries". In: *Proc. 5th International Workshop on Bibliometric-Enhanced Information Retrieval (BIR)*. Vol. 1823. CEUR Workshop Proceedings. CEUR-WS, 2017, pp. 51–61.

[28] F. Beierle, A. Aizawa, A. Collins, and J. Beel. "Choice Overload and Recommendation Effectiveness in Related-Article Recommendations". In: *International Journal on Digital Libraries* 21.3 (Sept. 2020), pp. 231–246. DOI: 10.1007/s00799-019-00270-7.

[29] F. Beierle and S. Egger. "MobRec – Mobile Platform for Decentralized Recommender Systems". In: *IEEE Access* 8 (2020), pp. 185311–185329. DOI: 10.1109/ACCESS.2020.3029319.

[30] F. Beierle and T. Eichinger. "Collaborating with Users in Proximity for Decentralized Mobile Recommender Systems". In: *Proc. IEEE 16th International Conference on Ubiquitous Intelligence and Computing (UIC)*. IEEE, June 2019, pp. 1192–1197. DOI: 10.1109/SmartWorld-UIC-ATC-SCALCOM-IOP-SCI.2019.00222.

[31] F. Beierle, S. Göndör, and A. Küpper. "Towards a Three-Tiered Social Graph in Decentralized Online Social Networks". In: *Proc. 7th International Workshop on Hot Topics in Planet-Scale mObile Computing and Online Social neTworking (HotPOST)*. ACM, June 2015, pp. 1–6. DOI: 10.1145/2757513.2757517.

[32] F. Beierle, K. Grunert, S. Göndör, and A. Küpper. "Privacy-Aware Social Music Playlist Generation". In: *Proc. 2016 IEEE International Conference on Communications (ICC)*. IEEE, 2016, pp. 5650–5656. DOI: 10.1109/ICC.2016.7511602.

[33] F. Beierle, K. Grunert, S. Göndör, and V. Schlüter. "Towards Psychometrics-Based Friend Recommendations in Social Networking Services". In: *2017 IEEE International Conference on AI & Mobile Services (AIMS)*. IEEE, June 2017, pp. 105–108. DOI: 10.1109/AIMS.2017.22.

[34] F. Beierle, S. C. Matz, and M. Allemand. "Smartphone Sensing in Personality Science". In: *Mobile Sensing in Psychology: Methods and Applications*. Ed. by M. R. Mehl, C. Wrzus, M. Eid, G. Harari, and U. E. Priemer. New York City, NY, USA: Guilford Press, 2021.

[35] F. Beierle, T. Probst, M. Allemand, J. Zimmermann, R. Pryss, P. Neff, W. Schlee, S. Stieger, and S. Budimir. "Frequency and Duration of Daily Smartphone Usage in Relation to Personality Traits". In: *Digital Psychology* 1.1 (2020), pp. 20–28. DOI: 10.24989/dp.v1i1.1821.

[36] F. Beierle, J. Tan, and K. Grunert. "Analyzing Social Relations for Recommending Academic Conferences". In: *Proc. 8th ACM International Workshop on Hot Topics in Planet-Scale mObile Computing and Online Social neTworking (HotPOST)*. ACM, 2016, pp. 37–42. DOI: 10.1145/2944789.2944871.

[37] F. Beierle, V. T. Tran, M. Allemand, P. Neff, W. Schlee, T. Probst, R. Pryss, and J. Zimmermann. "Context Data Categories and Privacy Model for Mobile Data Collection Apps". In: *Procedia Computer Science*. The 15th International Conference on Mobile Systems and Pervasive Computing (MobiSPC) 134 (2018), pp. 18–25. DOI: 10.1016/j.procs.2018.07.139.

[38] F. Beierle, V. T. Tran, M. Allemand, P. Neff, W. Schlee, T. Probst, R. Pryss, and J. Zimmermann. "TYDR – Track Your Daily Routine. Android App for Tracking Smartphone Sensor and Usage Data". In: *2018 IEEE/ACM 5th International Conference on Mobile Software Engineering and Systems (MOBILESoft)*. ACM, 2018, pp. 72–75. DOI: 10.1145/3197231.3197235.

[39] F. Beierle, V. T. Tran, M. Allemand, P. Neff, W. Schlee, T. Probst, J. Zimmermann, and R. Pryss. "What Data Are Smartphone Users Willing to Share with Researchers?" In: *Journal of Ambient Intelligence and Humanized Computing* 11 (2020), pp. 2277–2289. DOI: 10.1007/s12652-019-01355-6.

[40] D. Ben-Zeev, E. A. Scherer, R. Wang, H. Xie, and A. T. Campbell. "Next-Generation Psychiatric Assessment: Using Smartphone Sensors to Monitor Behavior and Mental Health". In: *Psychiatric rehabilitation journal* 38.3 (Sept. 2015), pp. 218–226. DOI: 10.1037/prj0000130.

[41] S. Berkovsky and J. Freyne. "Group-Based Recipe Recommendations: Analysis of Data Aggregation Strategies". In: *Proceedings of the Fourth ACM Conference on Recommender Systems*. RecSys '10. ACM, 2010, pp. 111–118. DOI: 10.1145/1864708.1864732.

[42] T. Bertin-Mahieux, D. P. Ellis, B. Whitman, and P. Lamere. "The Million Song Dataset". In: *Proceedings of the 12th International Society for Music Information Retrieval Conference (ISMIR)*. 2011.

[43] A. Bleicher. "The Anti-Facebook". In: *IEEE Spectrum* 48.6 (June 2011), pp. 54–82. DOI: 10.1109/MSPEC.2011.5779793.

[44] B. H. Bloom. "Space/Time Trade-Offs in Hash Coding with Allowable Errors". In: *Commun. ACM* 13.7 (July 1970), pp. 422–426. DOI: 10.1145/362686.362692.

[45] A. Bogomolov, B. Lepri, M. Ferron, F. Pianesi, and A. S. Pentland. "Daily Stress Recognition from Mobile Phone Data, Weather Conditions and Individual Traits". In: *Proceedings of the 22Nd ACM International Conference on Multimedia*. MM '14. ACM, 2014, pp. 477–486. DOI: 10.1145/2647868.2654933.

[46] D. E. Boubiche, M. Imran, A. Maqsood, and M. Shoaib. "Mobile Crowd Sensing – Taxonomy, Applications, Challenges, and Solutions". In: *Computers in Human Behavior* 101 (Dec. 2019), pp. 352–370. DOI: 10.1016/j.chb.2018.10.028.

[47] M. Boukhechba, Y. Huang, P. Chow, K. Fua, B. A. Teachman, and L. E. Barnes. "Monitoring Social Anxiety from Mobility and Communication Patterns". In: *Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers*. UbiComp '17. ACM, 2017, pp. 749–753. DOI: 10.1145/3123024.3125607.

[48] A. Boutet, S. Frenot, F. Laforest, P. Launay, N. Le Sommer, Y. Maheo, and D. Reimert. "C3PO: A Network and Application Framework for Spontaneous and Ephemeral Social Networks". In: *Web Information Systems Engineering – WISE 2015*. Ed. by J. Wang, W. Cellary, D. Wang, H. Wang, S.-C. Chen, T. Li, and Y. Zhang. Lecture Notes in Computer Science. Springer, 2015, pp. 348–358.

[49] D. M. Boyd and N. B. Ellison. "Social Network Sites: Definition, History, and Scholarship". In: *Journal of Computer-Mediated Communication* 13.1 (Oct. 2007), pp. 210–230. DOI: 10.1111/j.1083-6101.2007.00393.x.

[50] S. Burgess, E. Sanderson, and M. Umaña-Aponte. *School Ties: An Analysis of Homophily in an Adolescent Friendship Network*. CMPO Working Paper Series 11/267. Centre for Market and Public Organisation, 2011.

[51] J. Burke, D. Estrin, M. Hansen, A. Parker, N. Ramanathan, S. Reddy, and M. B. Srivastava. "Participatory Sensing". In: *Workshop on World-Sensor-Web (WSW'06): Mobile Device Centric Sensor Networks and Applications*. ACM, 2006, pp. 117–134.

[52] S. Butt and J. G. Phillips. "Personality and Self Reported Mobile Phone Use". In: *Computers in Human Behavior*. Part Special Issue: Cognition and Exploratory Learning in Digital Age 24.2 (Mar. 2008), pp. 346–360. DOI: 10.1016/j.chb.2007.01.019.

[53] D. Camps-Mur, A. Garcia-Saavedra, and P. Serrano. "Device-to-Device Communications with Wi-Fi Direct: Overview and Experimentation". In: *IEEE Wireless Communications* 20.3 (June 2013), pp. 96–104. DOI: 10.1109/MWC.2013.6549288.

[54] L. Canzian and M. Musolesi. "Trajectories of Depression: Unobtrusive Monitoring of Depressive States by Means of Smartphone Mobility Traces Analysis". In: *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*. UbiComp '15. ACM, 2015, pp. 1293–1304. DOI: 10.1145/2750858.2805845.

[55] B. Cao, L. Zheng, C. Zhang, P. S. Yu, A. Piscitello, J. Zulueta, O. Ajilore, K. Ryan, and A. D. Leow. "DeepMood: Modeling Mobile Phone Typing Dynamics for Mood Detection". In: *Proceedings of the 23rd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*. KDD '17. Association for Computing Machinery, Aug. 2017, pp. 747–755. DOI: 10.1145/3097983.3098086.

[56] D. Carneiro, A. P. Pinheiro, and P. Novais. "Context Acquisition in Auditory Emotional Recognition Studies". In: *Journal of Ambient Intelligence and Humanized Computing* 8.2 (Apr. 2017), pp. 191–203. DOI: 10.1007/s12652-016-0391-2.

[57] A. C. Champion, Z. Yang, B. Zhang, J. Dai, D. Xuan, and D. Li. "E-SmallTalker: A Distributed Mobile System for Social Networking in Physical Proximity". In: *IEEE Transactions on Parallel and Distributed Systems* 24.8 (Aug. 2013), pp. 1535–1545. DOI: 10.1109/TPDS.2012.251.

[58] C. Chang, S. N. Srirama, and S. Ling. "An Adaptive Mediation Framework for Mobile P2P Social Content Sharing". In: *Service-Oriented Computing*. Ed. by C. Liu, H. Ludwig, F. Toumani, and Q. Yu. Lecture Notes in Computer Science 7636. Springer Berlin Heidelberg, 2012, pp. 374–388.

[59] A. Chin. "Ephemeral Social Networks". In: *Mobile Social Networking: An Innovative Approach*. Ed. by A. Chin and D. Zhang. Computational Social Sciences. Springer, 2014, pp. 25–64. DOI: 10.1007/978-1-4614-8579-7_3.

[60] A. Chin, H. Wang, B. Xu, K. Zhang, H. Wang, and L. Zhu. "Connecting People in the Workplace through Ephemeral Social Networks". In: *2011 IEEE Third International Conference on Privacy, Security, Risk and Trust and 2011 IEEE Third International Conference on Social Computing*. Oct. 2011, pp. 527–530. DOI: 10.1109/PASSAT/SocialCom.2011.88.

[61] A. Chin, B. Xu, and H. Wang. "Who Should I Add as a "Friend"? A Study of Friend Recommendations Using Proximity and Homophily". In: *Proceedings of the 4th International Workshop on Modeling Social Media*. MSM '13. Association for Computing Machinery, May 2013, pp. 1–7. DOI: 10.1145/2463656.2463663.

[62] A. Chin, B. Xu, F. Yin, X. Wang, W. Wang, X. Fan, D. Hong, and Y. Wang. "Using Proximity and Homophily to Connect Conference Attendees in a Mobile Social Network". In: *2012 32nd International Conference on Distributed Computing Systems Workshops*. June 2012, pp. 79–87. DOI: 10.1109/ICDCSW.2012.56.

[63] G. Chittaranjan, J. Blom, and D. Gatica-Perez. "Who's Who with Big-Five: Analyzing and Classifying Personality Traits with Smartphones". In: *Proc. 2011 15th Annual International Symposium on Wearable Computers*. IEEE, June 2011, pp. 29–36. DOI: 10.1109/ISWC.2011.29.

[64] G. Chittaranjan, J. Blom, and D. Gatica-Perez. "Mining Large-Scale Smartphone Data for Personality Studies". In: *Personal and Ubiquitous Computing* 17.3 (Mar. 2013), pp. 433–450. DOI: 10.1007/s00779-011-0490-1.

[65] S. Cho and C. Julien. "Chitchat: Navigating Tradeoffs in Device-to-Device Context Sharing". In: *2016 IEEE International Conference on Pervasive Computing and Communications (PerCom)*. IEEE, Mar. 2016, pp. 1–10. DOI: 10.1109/PERCOM.2016.7456512.

[66] M. J. Chorley, R. M. Whitaker, and S. M. Allen. "Personality and Location-Based Social Networks". In: *Computers in Human Behavior* 46.Supplement C (May 2015), pp. 45–56. DOI: 10.1016/j.chb.2014.12.038.

[67] N. Confessore and D. Hakim. "Data Firm Says 'Secret Sauce' Aided Trump; Many Scoff". In: *The New York Times* (Mar. 2017).

[68] G. Cormode and S. Muthukrishnan. "An Improved Data Stream Summary: The Count-Min Sketch and Its Applications". In: *LATIN 2004: Theoretical Informatics*. Springer, 2004, pp. 29–38.

[69] P. J. Corr and G. Matthews. "The Cambridge Handbook of Personality Psychology". In: *The Cambridge Handbook of Personality Psychology*. Ed. by P. J. Corr and G. Matthews. Cambridge University Press, 2009, pp. xxii–xlii. DOI: 10.1017/CBO9780511596544.002.

[70] P. T. Costa Jr. and R. R. McCrae. "The Revised NEO Personality Inventory (NEO-PI-R)". In: *The SAGE Handbook of Personality Theory and Assessment: Volume 2 — Personality Measurement and Testing*. SAGE Publications Ltd, 2008, pp. 179–198. DOI: 10.4135/9781849200479.

[71] A. Crossen, J. Budzik, and K. J. Hammond. "Flytrap: Intelligent Group Music Recommendation". In: *Proceedings of the 7th International Conference on Intelligent User Interfaces*. ACM, 2002, pp. 184–185.

[72] D. Danner, B. Rammstedt, M. Bluemke, L. Treiber, S. Berres, C. Soto, and O. John. *Die Deutsche Version Des Big Five Inventory 2 (BFI-2)*. Zusammenstellung Sozialwissenschaftlicher Items Und Skalen. 2016. DOI: 10.6102/zis247.

[73] A. Datta, S. Buchegger, L.-H. Vu, T. Strufe, and K. Rzadca. "Decentralized Online Social Networks". In: *Handbook of Social Network Technologies and Applications*. Springer, 2010, pp. 349–378.

[74] N. Davies, A. Friday, P. Newman, S. Rutlidge, and O. Storz. "Using Bluetooth Device Names to Support Interaction in Smart Environments". In: *Proceedings of the 7th International Conference on Mobile Systems, Applications, and Services*. MobiSys '09. ACM, 2009, pp. 151–164. DOI: 10.1145/1555816.1555832.

[75] Y.-A. de Montjoye, J. Quoidbach, F. Robic, and A. S. Pentland. "Predicting Personality Using Novel Mobile Phone-Based Metrics". In: *Social Computing, Behavioral-Cultural Modeling and Prediction*. Ed. by A. M. Greenberg, W. G. Kennedy, and N. D. Bos. Lecture Notes in Computer Science. Springer, 2013, pp. 48–55. DOI: 10.1007/978-3-642-37210-0_6.

[76] I. Denisow, S. Zickau, F. Beierle, and A. Küpper. "Dynamic Location Information in Attribute-Based Encryption Schemes". In: *Proc. 9th International Conference on Next Generation Mobile Applications, Services and Technologies (NGMAST)*. IEEE, 2015, pp. 240–247. DOI: 10.1109/NGMAST.2015.63.

[77] A. K. Dey. "Understanding and Using Context". In: *Personal Ubiquitous Comput.* 5.1 (Jan. 2001), pp. 4–7. DOI: 10.1007/s007790170019.

[78] C. G. DeYoung. "Openness/Intellect: A Dimension of Personality Reflecting Cognitive Exploration." In: *APA Handbook of Personality and Social Psychology, Volume 4: Personality Processes and Individual Differences*. Ed. by M. Mikulincer, P. R. Shaver, M. L. Cooper, and R. J. Larsen. American Psychological Association, 2015, pp. 369–399. DOI: 10.1037/14343-017.

[79] D. Di Matteo, A. Fine, K. Fotinos, J. Rose, and M. Katzman. "Patient Willingness to Consent to Mobile Phone Data Collection for Mental Health Apps: Structured Questionnaire". In: *JMIR Mental Health* 5.3 (Aug. 2018). DOI: 10.2196/mental.9539.

[80] H. Dinh-Tuan, F. Beierle, and S. Rodriguez Garzon. "MAIA: A Microservices-Based Architecture for Industrial Data Analytics". In: *Proc. 2019 IEEE International Conference on Industrial Cyber Physical Systems (ICPS)*. IEEE, May 2019, pp. 23–30. DOI: 10.1109/ICPHYS.2019.8780345.

[81] H. Dinh-Tuan, M. Mora-Martinez, F. Beierle, and S. Rodriguez Garzon. "Development Frameworks for Microservice-based Applications: Evaluation and Comparison". In: *Proc. 2020 European Symposium on Software Engineering (ESSE)*. ACM, Nov. 2020, pp. 12–20. DOI: 10.1145/3393822.3432339.

[82] B. Dodson, I. Vo, T. Purtell, A. Cannon, and M. Lam. "Musubi: Disintermediated Interactive Social Feeds for Mobile Devices". In: *Proceedings of the 21st International Conference on World Wide Web*. WWW '12. ACM, 2012, pp. 211–220. DOI: 10.1145/2187836.2187866.

[83] C. Dong, L. Chen, and Z. Wen. "When Private Set Intersection Meets Big Data: An Efficient and Scalable Protocol". In: *Proceedings of the 2013 ACM SIGSAC Conference on Computer & Communications Security*. CCS '13. ACM, 2013, pp. 789–800. DOI: 10.1145/2508859.2516701.

[84] B. Donnet, B. Gueye, and M. A. Kaafar. "Path Similarity Evaluation Using Bloom Filters". In: *Computer Networks* 56.2 (2012), pp. 858–869.

[85] D. J. Dubois, Y. Bando, K. Watanabe, and H. Holtzman. "ShAir: Extensible Middleware for Mobile Peer-to-Peer Resource Sharing". In: *Proceedings of the 2013 9th Joint Meeting on Foundations of Software Engineering*. ESEC/FSE 2013. ACM, 2013, pp. 687–690. DOI: 10.1145/2491411.2494573.

[86] N. Eagle and A. Pentland. "Social Serendipity: Mobilizing Social Software". In: *Pervasive Computing, IEEE* 4.2 (2005), pp. 28–34.

[87] N. Eagle and A. S. Pentland. "Reality Mining: Sensing Complex Social Systems". In: *Personal and Ubiquitous Computing* 10.4 (May 2006), pp. 255–268. DOI: 10.1007/s00779-005-0046-3.

[88] S. Egger. *Design and Implementation of a Mobile Platform for Recommender Systems*. Master's Thesis. Technische Universität Berlin. 2019.

[89] T. Eichinger, F. Beierle, S. U. Khan, R. Middelanis, S. Veeraraghavan, and S. Tabibzadeh. "Affinity: A System for Latent User Similarity Comparison on Texting Data". In: *Proc. 2019 IEEE International Conference on Communications (ICC)*. IEEE, May 2019, pp. 1–7. DOI: 10.1109/ICC.2019.8761051.

[90] T. Eichinger, F. Beierle, R. Papke, L. Rebscher, H. C. Tran, and M. Trzeciak. "On Gossip-Based Information Dissemination in Pervasive Recommender Systems". In: *Prod. 13th ACM Conference on Recommender Systems (RecSys)*. ACM, Sept. 2019, pp. 442–446. DOI: 10.1145/3298689.3347067.

[91] C. K. Enders and D. Tofighi. "Centering Predictor Variables in Cross-Sectional Multilevel Models: A New Look at an Old Issue." In: *Psychological Methods* 12.2 (2007), pp. 121–138. DOI: 10.1037/1082-989X.12.2.121.

[92] P. Eskes, M. Spruit, S. Brinkkemper, J. Vorstman, and M. J. Kas. "The Sociability Score: App-Based Social Profiling from a Healthcare Perspective". In: *Computers in Human Behavior* 59 (June 2016), pp. 39–48. DOI: 10.1016/j.chb.2016.01.024.

[93] R. Esmaeilyfard and F. Hendessi. "An Affective Ephemeral Social Network for Vehicular Scenarios". In: *Journal of Ambient Intelligence and Smart Environments* 7.1 (2015), pp. 21–36.

[94] M. Falch, A. Henten, R. Tadayoni, and I. Windekilde. "Business Models in Social Networking". In: *CMI Int. Conf. on Social Networking and Communities*. 2009.

[95] L. Fan, P. Cao, J. Almeida, and A. Z. Broder. "Summary Cache: A Scalable Wide-Area Web Cache Sharing Protocol". In: *IEEE/ACM Transactions on Networking* 8.3 (June 2000), pp. 281–293. DOI: 10.1109/90.851975.

[96] R. Farahbakhsh, X. Han, A. Cuevas, and N. Crespi. "Analysis of Publicly Disclosed Information in Facebook Profiles". In: *Proc. 2013 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM)*. ACM, Aug. 2013, pp. 699–705.

[97] A. A. Farhan, C. Yue, R. Morillo, S. Ware, J. Lu, J. Bi, J. Kamath, A. Russell, A. Bamis, and B. Wang. "Behavior vs. Introspection: Refining Prediction of Clinical Depression via Smartphone Sensing Data". In: *2016 IEEE Wireless Health (WH)*. IEEE, Oct. 2016, pp. 1–8. DOI: 10.1109/WH.2016.7764553.

[98] M. A. Ferrag, L. Maglaras, and A. Ahmim. "Privacy-Preserving Schemes for Ad Hoc Social Networks: A Survey". In: *IEEE Communications Surveys Tutorials* 19.4 (Fourthquarter 2017), pp. 3015–3045. DOI: 10.1109/COMST.2017.2718178.

[99] D. Ferreira, V. Kostakos, and A. K. Dey. "AWARE: Mobile Context Instrumentation Framework". In: *Frontiers in ICT* 2 (2015). DOI: 10.3389/fict.2015.00006.

[100] L. Festinger, S. Schachter, and K. Back. "The Spatial Ecology of Group Formation". In: *Social pressures in informal groups.* Social Pressures in Informal Groups (1950), pp. 141–161.

[101] A. R. Filippo. "Innovating in Uncertainty: Effective Compliance and the GDPR". In: *Harvard Journal of Law & Technology* (2018). https://jolt.law.harvard.edu/digest/innovating-in-uncertainty-effective-compliance-and-the-gdpr.

[102] C. S. Fischer. *To Dwell Among Friends: Personal Networks in Town and City.* University of Chicago Press, Apr. 1982.

[103] W. Fleeson. "Toward a Structure-and Process-Integrated View of Personality: Traits as Density Distributions of States". In: *Journal of Personality and Social Psychology* 80.6 (2001), pp. 1011–1027. DOI: 10.1037/0022-3514.80.6.1011.

[104] I. Friese, R. Copeland, S. Göndör, F. Beierle, A. Küpper, R. L. Pereira, and J.-M. Crom. "Cross-Domain Discovery of Communication Peers: Identity Mapping and Discovery Services (IMaDS)". In: *Proc. 2017 European Conference on Networks and Communications (EuCNC).* IEEE, June 2017, pp. 1–6. DOI: 10.1109/EuCNC.2017.7980642.

[105] J. Froehlich, M. Y. Chen, I. E. Smith, and F. Potter. "Voting with Your Feet: An Investigative Study of the Relationship Between Place Visit Behavior and Preference". In: *UbiComp 2006: Ubiquitous Computing.* Ed. by P. Dourish and A. Friday. Lecture Notes in Computer Science. Springer, 2006, pp. 333–350. DOI: 10.1007/11853565_20.

[106] C. Fuentes, V. Herskovic, I. Rodríguez, C. Gerea, M. Marques, and P. O. Rossel. "A Systematic Literature Review about Technologies for Self-Reporting Emotional Information". In: *Journal of Ambient Intelligence and Humanized Computing* 8.4 (Aug. 2017), pp. 593–606. DOI: 10.1007/s12652-016-0430-z.

[107] D. C. Funder. "Accurate Personality Judgment". In: *Current Directions in Psychological Science* 21.3 (June 2012), pp. 177–182. DOI: 10.1177/0963721412445309.

[108] S. Gambs, M.-O. Killijian, and M. N. d. P. Cortez. "Show Me How You Move and I Will Tell You Who You Are". In: *Trans. Data Privacy* 4 (2010), pp. 103–126. DOI: 10.1145/1868470.1868479.

[109] R. K. Ganti, F. Ye, and H. Lei. "Mobile Crowdsensing: Current State and Future Challenges". In: *IEEE Communications Magazine* 49.11 (Nov. 2011), pp. 32–39. DOI: 10.1109/MCOM.2011.6069707.

[110] C.-z. Gao, Q. Cheng, X. Li, and S.-b. Xia. "Cloud-Assisted Privacy-Preserving Profile-Matching Scheme under Multiple Keys in Mobile Social Network". In: *Cluster Computing* 22.1 (Jan. 2019), pp. 1655–1663. DOI: 10.1007/s10586-017-1649-y.

[111] J. Golbeck, C. Robles, and K. Turner. "Predicting Personality with Social Media". In: *Proc. CHI '11 Extended Abstracts on Human Factors in Computing Systems (CHI EA'11)*. CHI EA '11. ACM, May 2011, pp. 253–262. DOI: 10.1145/1979742.1979614.

[112] L. R. Goldberg, J. A. Johnson, H. W. Eber, R. Hogan, M. C. Ashton, C. R. Cloninger, and H. G. Gough. "The International Personality Item Pool and the Future of Public-Domain Personality Measures". In: *Journal of Research in Personality*. Proceedings of the 2005 Meeting of the Association of Research in Personality 40.1 (Feb. 2006), pp. 84–96. DOI: 10.1016/j.jrp.2005.08.007.

[113] S. Göndör, F. Beierle, E. Kücükbayraktar, H. Hebbo, S. Sharhan, and A. Küpper. "Towards Migration of User Profiles in the SONIC Online Social Network Federation". In: *Proc. International Multi-Conference on Computing in the Global Information Technology (ICCGI)*. IARIA, 2015, pp. 1–5.

[114] S. Göndör, F. Beierle, S. Sharhan, H. Hebbo, E. Kücükbayraktar, and A. Küpper. "SONIC: Bridging the Gap between Different Online Social Network Platforms". In: *Proc. 2015 IEEE International Conference on Smart*

City/SocialCom/SustainCom (SmartCity). IEEE, Dec. 2015, pp. 399–406. DOI: 10.1109/SmartCity.2015.104.

[115] S. Göndör, F. Beierle, S. Sharhan, and A. Küpper. "Distributed and Domain-Independent Identity Management for User Profiles in the SONIC Online Social Network Federation". In: *International Conference on Computational Social Networks (CSoNet)*. Ed. by H. T. Nguyen and V. Snasel. Vol. 9795. LNCS. Springer, 2016, pp. 226–238. DOI: 10.1007/978-3-319-42345-6_20.

[116] S. J. Göndör. "Seamless Interoperability and Data Portability in the Social Web for Facilitating an Open and Heterogeneous Online Social Network Federation". PhD thesis. Technische Universität Berlin, 2018.

[117] S. D. Gosling, S. Gaddis, and S. Vazire. "Personality Impressions Based on Facebook Profiles". In: *Proc. International AAAI Conference on Weblogs and Social Media (ICWSM)*. AAAI, 2007, pp. 1–4.

[118] F. M. Götz, S. Stieger, and U.-D. Reips. "Users of the Main Smartphone Operating Systems (iOS, Android) Differ Only Little in Personality". In: *PLOS ONE* 12.5 (Mar. 2017), e0176921. DOI: 10.1371/journal.pone.0176921.

[119] S. Greenwood, A. Perrin, and M. Duggan. *Social Media Update 2016*. http://www.pewinternet.org/2016/11/11/social-media-update-2016/. Nov. 2016.

[120] T. Grover and G. Mark. "Digital Footprints: Predicting Personality from Temporal Patterns of Technology Use". In: *Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers*. UbiComp '17. ACM, 2017, pp. 41–44. DOI: 10.1145/3123024.3123139.

[121] I. Guy. "People Recommendation on Social Media". In: *Social Information Access: Systems and Technologies*. Ed. by P. Brusilovsky and D. He. Lecture Notes in Computer Science. Springer International Publishing, 2018, pp. 570–623. DOI: 10.1007/978-3-319-90092-6_15.

[122] J. Haikio, T. Tuikka, E. Siira, and V. Tormanen. "'Would You Be My Friend?' - Creating a Mobile Friend Network with 'Hot in the City'". In: *2010 43rd Hawaii*

International Conference on System Sciences. Jan. 2010, pp. 1–10. DOI: 10.1109/HICSS.2010.2.

[123] S. Halko and J. A. Kientz. "Personality and Persuasive Technology: An Exploratory Study on Health-Promoting Mobile Applications". In: *Persuasive Technology*. Ed. by D. Hutchison, T. Kanade, J. Kittler, J. M. Kleinberg, F. Mattern, J. C. Mitchell, M. Naor, O. Nierstrasz, C. Pandu Rangan, B. Steffen, M. Sudan, D. Terzopoulos, D. Tygar, M. Y. Vardi, G. Weikum, T. Ploug, P. Hasle, and H. Oinas-Kukkonen. Vol. 6137. Springer Berlin Heidelberg, 2010, pp. 150–161. DOI: 10.1007/978-3-642-13226-1_16.

[124] F. Hao, S. Li, G. Min, H.-C. Kim, S. S. Yau, and L. T. Yang. "An Efficient Approach to Generating Location-Sensitive Recommendations in Ad-Hoc Social Network Environments". In: *IEEE Transactions on Services Computing* 8.3 (May 2015), pp. 520–533. DOI: 10.1109/TSC.2015.2401833.

[125] G. M. Harari, N. D. Lane, R. Wang, B. S. Crosier, A. T. Campbell, and S. D. Gosling. "Using Smartphones to Collect Behavioral Data in Psychological Science: Opportunities, Practical Considerations, and Challenges". In: *Perspectives on Psychological Science* 11.6 (Nov. 2016), pp. 838–854. DOI: 10.1177/1745691616650285.

[126] G. M. Harari, S. R. Müller, M. S. Aung, and P. J. Rentfrow. "Smartphone Sensing Methods for Studying Behavior in Everyday Life". In: *Current Opinion in Behavioral Sciences*. SI: 18: Big Data in the Behavioural Sciences (2017) 18.Supplement C (Dec. 2017), pp. 83–90. DOI: 10.1016/j.cobeha.2017.07.018.

[127] G. M. Harari, S. R. Müller, C. Stachl, R. Wang, W. Wang, M. Bühner, P. J. Rentfrow, A. T. Campbell, and S. D. Gosling. "Sensing Sociability: Individual Differences in Young Adults' Conversation, Calling, Texting, and App Use Behaviors in Daily Life". In: *Journal of Personality and Social Psychology* (May 2019). DOI: 10.1037/pspp0000245.

[128] M. Hashemi and J. Herbert. "A Next Application Prediction Service Using the BaranC Framework". In: *Proc. 2016 IEEE 40th Annual Computer Software and Applications Conference (COMPSAC)*. IEEE, June 2016, pp. 519–523. DOI: 10.1109/COMPSAC.2016.30.

[129] M. Hashemi and J. Herbert. "User Interaction Monitoring and Analysis Framework". In: *Proc. 2016 IEEE/ACM International Conference on Mobile Software Engineering and Systems (MobileSoft '16)*. ACM, 2016, pp. 7–8. DOI: 10.1145/2897073.2897108.

[130] W. He, Y. Huang, K. Nahrstedt, and B. Wu. "Message Propagation in Ad-Hoc-Based Proximity Mobile Social Networks". In: *2010 8th IEEE International Conference on Pervasive Computing and Communications Workshops (PERCOM Workshops)*. Mar. 2010, pp. 141–146. DOI: 10.1109/PERCOMW.2010.5470617.

[131] J. Heidemann, M. Klier, and F. Probst. "Online Social Networks: A Survey of a Global Phenomenon". In: *Computer Networks* 56.18 (Dec. 2012), pp. 3866–3878. DOI: 10.1016/j.comnet.2012.08.009.

[132] D. M. Higgins, J. B. Peterson, R. O. Pihl, and A. G. M. Lee. "Prefrontal Cognitive Ability, Intelligence, Big Five Personality, and the Prediction of Advanced Academic and Workplace Performance." In: *Journal of Personality and Social Psychology* 93.2 (Aug. 2007), pp. 298–319. DOI: 10.1037/0022-3514.93.2.298.

[133] J. Hinds and A. Joinson. "Human and Computer Personality Prediction From Digital Footprints". In: *Current Directions in Psychological Science* 28.2 (Apr. 2019), pp. 204–211. DOI: 10.1177/0963721419827849.

[134] J. B. Hirsh, C. G. DeYoung, and J. B. Peterson. "Metatraits of the Big Five Differentially Predict Engagement and Restraint of Behavior". In: *Journal of Personality* 77.4 (2009), pp. 1085–1102. DOI: 10.1111/j.1467-6494.2009.00575.x.

[135] X. Hu, T. H. S. Chu, V. C. M. Leung, E. C.-H. Ngai, P. Kruchten, and H. C. B. Chan. "A Survey on Mobile Social Networks: Applications, Platforms, System Architectures, and Future Research Directions". In: *IEEE Communications Surveys & Tutorials* 17.3 (2015), pp. 1557–1581. DOI: 10.1109/COMST.2014.2371813.

[136] Y. Huang, H. Xiong, K. Leach, Y. Zhang, P. Chow, K. Fua, B. A. Teachman, and L. E. Barnes. "Assessing Social Anxiety Using GPS Trajectories and Point-Of-Interest Data". In: *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing*. UbiComp '16. Association for Computing Machinery, Sept. 2016, pp. 898–903. DOI: 10.1145/2971648.2971761.

[137] G. C.-L. Hung, P.-C. Yang, C.-C. Chang, J.-H. Chiang, and Y.-Y. Chen. "Predicting Negative Emotions Based on Mobile Phone Usage Patterns: An Exploratory Study". In: *JMIR Research Protocols* 5.3 (Aug. 2016), e160. DOI: 10.2196/resprot.5551.

[138] T. R. Insel. "Digital Phenotyping: Technology for a New Science of Behavior". In: *JAMA* 318.13 (Oct. 2017), pp. 1215–1216. DOI: 10.1001/jama.2017.11295.

[139] N. Jain, M. Dahlin, and R. Tewari. "Using Bloom Filters to Refine Web Search Results". In: *WebDB*. 2005, pp. 25–30.

[140] I. T. Javed, R. Copeland, N. Crespi, F. Beierle, S. Göndör, A. Küpper, M. Emmelmann, A. Corici, K. Corre, J.-M. Crom, A. Bouabdallah, F. Oberle, I. Friese, A. Caldeira, G. Dias, R. Chaves, and N. Santo. "Global Identity and Reachability Framework for Interoperable P2P Communication Services". In: *Proc. 2016 Conference on Innovations in Clouds, Internet and Networks (ICIN)*. IFIP, 2016, pp. 59–66.

[141] I. T. Javed, R. Copeland, N. Crespi, M. Emmelmann, A. Corici, A. Bouabdallah, T. Zhang, S. El Jaouhari, F. Beierle, S. Göndör, A. Küpper, K. Corre, J.-M. Crom, F. Oberle, I. Friese, A. Caldeira, G. Dias, N. Santos, R. Chaves, and R. L. Pereira. "Cross-Domain Identity and Discovery Framework for Web Calling Services". In: *Annals of Telecommunications* 72.7 (Aug. 2017), pp. 459–468. DOI: 10.1007/s12243-017-0587-2.

[142] K. Jayarajah, R. K. Balan, M. Radhakrishnan, A. Misra, and Y. Lee. "LiveLabs: Building In-Situ Mobile Sensing & Behavioural Experimentation TestBeds". In: *Proceedings of the 14th Annual International Conference on Mobile Systems, Applications, and Services*. MobiSys '16. ACM, 2016, pp. 1–15. DOI: 10.1145/2906388.2906400.

[143] B. F. Jeronimus, H. Riese, R. Sanderman, and J. Ormel. "Mutual Reinforcement between Neuroticism and Life Experiences: A Five-Wave, 16-Year Study to Test Reciprocal Causation". In: *Journal of Personality and Social Psychology* 107.4 (2014), pp. 751–764. DOI: 10.1037/a0037009.

[144] O. P. John and S. Srivastava. "The Big Five Trait Taxonomy: History, Measurement, and Theoretical Perspectives". In: *Handbook of Personality, Second Edition: Theory and Research*. Guilford Press, 1999, pp. 102–138.

[145] Q. Jones and S. Grandhi. "P3 Systems: Putting the Place Back into Social Networks". In: *IEEE Internet Computing* 9.5 (Sept. 2005), pp. 38–46. DOI: 10.1109/MIC.2005.105.

[146] J. T. Jost. "The End of the End of Ideology." In: *American Psychologist* 61.7 (2006), pp. 651–670. DOI: 10.1037/0003-066X.61.7.651.

[147] J. Joy, E. Chung, Z. Yuan, J. Li, L. Zou, and M. Gerla. "DiscoverFriends: Secure Social Network Communication in Mobile Ad Hoc Networks". In: *Wireless Communications and Mobile Computing* 16.11 (2016), pp. 1401–1413. DOI: 10.1002/wcm.2708.

[148] S. M. Kala, V. Sathya, S. S. Magdum, T. V. K. Buyakar, H. Lokhandwala, and B. R. Tamma. "Designing Infrastructure-Less Disaster Networks by Leveraging the AllJoyn Framework". In: *Proceedings of the 20th International Conference on Distributed Computing and Networking*. ICDCN '19. ACM, 2019, pp. 417–420. DOI: 10.1145/3288599.3295596.

[149] F. Kargl, R. W. van der Heijden, B. Erb, and C. Bösch. "Privacy in Mobile Sensing". In: *Digital Phenotyping and Mobile Sensing: New Developments in Psychoinformatics*. Ed. by H. Baumeister and C. Montag. Studies in Neuroscience, Psychology and Behavioral Economics. Springer, 2019, pp. 3–12. DOI: 10.1007/978-3-030-31620-4_1.

[150] R. P. Karumur, T. T. Nguyen, and J. A. Konstan. "Personality, User Preferences and Behavior in Recommender Systems". In: *Information Systems Frontiers* (Sept. 2017), pp. 1–25. DOI: 10.1007/s10796-017-9800-0.

[151] N. Kayastha, D. Niyato, P. Wang, and E. Hossain. "Applications, Architectures, and Protocol Design Issues for Mobile Social Networks: A Survey". In: *Proceedings of the IEEE* 99.12 (Dec. 2011), pp. 2130–2158. DOI: 10.1109/JPROC.2011.2169033.

[152] F. Kerschbaum. "Outsourced Private Set Intersection Using Homomorphic Encryption". In: *Proceedings of the 7th ACM Symposium on Information, Computer and Communications Security*. ASIACCS '12. ACM, 2012, pp. 85–86. DOI: 10.1145/2414456.2414506.

[153] S. Y. Kim, H. J. Koo, and H. Y. Song. "A Study on Estimation of Human Personality from Location Visiting Preference". In: *Journal of Ambient Intelligence and Humanized Computing* 9.3 (June 2018), pp. 629–642. DOI: 10.1007/s12652-017-0459-7.

[154] N. Kiukkonen, J. Blom, O. Dousse, D. Gatica-Perez, and J. Laurila. "Towards Rich Mobile Phone Datasets: Lausanne Data Collection Campaign". In: *Proc. ACM Intl. Conf. on Pervasive Computing (ICPS)*. 2010.

[155] M. Kosinski, D. Stillwell, and T. Graepel. "Private Traits and Attributes Are Predictable from Digital Records of Human Behavior". In: *Proceedings of the National Academy of Sciences* 110.15 (Apr. 2013), pp. 5802–5805. DOI: 10.1073/pnas.1218772110.

[156] R. Kraft, W. Schlee, M. Stach, M. Reichert, B. Langguth, H. Baumeister, T. Probst, R. Hannemann, and R. Pryss. "Combining Mobile Crowdsensing and Ecological Momentary Assessments in the Healthcare Domain". In: *Frontiers in Neuroscience* 14.164 (2020). DOI: 10.3389/fnins.2020.00164.

[157] R. Kraut, C. Egido, and J. Galegher. "Patterns of Contact and Communication in Scientific Research Collaboration". In: *Proceedings of the 1988 ACM Conference on Computer-Supported Cooperative Work - CSCW '88*. ACM Press, 1988, pp. 1–12. DOI: 10.1145/62266.62267.

[158] A. Küpper, U. Bareth, and B. Freese. "Geofencing and Background Tracking – The Next Features in LBSs". In: *Informatik 2011 - Informatik Schafft Communities*. Vol. 192. LNCI. 2011, p. 14.

[159] K. Kwan and B. Greaves. "FileLinker: Simple Peer-to-Peer File Sharing Using Wi-Fi Direct and NFC". In: *2019 IST-Africa Week Conference (IST-Africa)*. May 2019, pp. 1–9. DOI: 10.23919/ISTAFRICA.2019.8764840.

[160] C. A. Lampe, N. Ellison, and C. Steinfield. "A Familiar Face(Book): Profile Elements As Signals in an Online Social Network". In: *Proc. SIGCHI Conference on Human Factors in Computing Systems (CHI 2007)*. ACM, Apr. 2007, pp. 435–444. DOI: 10.1145/1240624.1240695.

[161] K. Lanaj, R. E. Johnson, and C. M. Barnes. "Beginning the Workday yet Already Depleted? Consequences of Late-Night Smartphone Use and Sleep". In: *Organizational Behavior and Human Decision Processes* 124.1 (2014), pp. 11–23. DOI: 10.1016/j.obhdp.2014.01.001.

[162] N. D. Lane, E. Miluzzo, H. Lu, D. Peebles, T. Choudhury, and A. T. Campbell. "A Survey of Mobile Phone Sensing". In: *IEEE Communications Magazine* 48.9 (Sept. 2010), pp. 140–150. DOI: 10.1109/MCOM.2010.5560598.

[163] W. Lane and C. Manner. "The Influence of Personality Traits on Mobile Phone Application Preferences". In: *Journal of Economics & Behavioral Studies* 4.5 (2012), pp. 252–260.

[164] S. Langer and J. Beel. "The Comparability of Recommender System Evaluations and Characteristics of Docear's Users". In: *Proc. Workshop on Recommender Systems Evaluation: Dimensions and Design (REDD) at the 2014 ACM Conference Series on Recommender Systems (RecSys)*. ACM, 2014, pp. 1–6.

[165] F. Laport-López, E. Serrano, J. Bajo, and A. T. Campbell. "A Review of Mobile Sensing Systems, Applications, and Opportunities". In: *Knowledge and Information Systems* (Mar. 2019). DOI: 10.1007/s10115-019-01346-1.

[166] R. Larson and M. Csikszentmihalyi. "The Experience Sampling Method". In: *Flow and the Foundations of Positive Psychology: The Collected Works of Mihaly Csikszentmihalyi*. Ed. by H. Reis. Vol. Flow and the Foundations of Positive Psychology. Springer, 2014, pp. 41–56. DOI: 10.1007/978-94-017-9088-8_2.

[167] Y. Li, Y. Zhao, S. Ishak, H. Song, N. Wang, and N. Yao. "An Anonymous Data Reporting Strategy with Ensuring Incentives for Mobile Crowd-Sensing". In: *Journal of Ambient Intelligence and Humanized Computing* 9.6 (Nov. 2018), pp. 2093–2107. DOI: 10.1007/s12652-017-0529-x.

[168] R. LiKamWa, Y. Liu, N. D. Lane, and L. Zhong. "MoodScope: Building a Mood Sensor from Smartphone Usage Patterns". In: *Proceeding of the 11th Annual International Conference on Mobile Systems, Applications, and Services*. MobiSys '13. ACM, 2013, pp. 389–402. DOI: 10.1145/2462456.2464449.

[169] H. Liu. "Social Network Profiles as Taste Performances". In: *Journal of Computer-Mediated Communication* 13.1 (Oct. 2007), pp. 252–275. DOI: 10.1111/j.1083-6101.2007.00395.x.

[170] H. Lokhandwala, S. M. Kala, and B. R. Tamma. "Min-O-Mee: A Proximity Based Network Application Leveraging the AllJoyn Framework". In: *2015 International Conference on Computing and Network Communications (CoCoNet)*. Dec. 2015, pp. 613–619. DOI: 10.1109/CoCoNet.2015.7411252.

[171] G. López, G. Marín, and M. Calderón. "Human Aspects of Ubiquitous Computing: A Study Addressing Willingness to Use It and Privacy Issues". In: *Journal of Ambient Intelligence and Humanized Computing* 8.4 (Aug. 2017), pp. 497–511. DOI: 10.1007/s12652-016-0438-4.

[172] H.-P. Lu and K.-L. Hsiao. "The Influence of Extro/Introversion on the Intention to Pay for Social Networking Sites". In: *Information & Management* 47.3 (Apr. 2010), pp. 150–157. DOI: 10.1016/j.im.2010.01.003.

[173] Z. Lu, G. Cao, and T. L. Porta. "Networking Smartphones for Disaster Recovery". In: *2016 IEEE International Conference on Pervasive Computing and Communications (PerCom)*. IEEE, Mar. 2016, pp. 1–9. DOI: 10.1109/PERCOM.2016.7456503.

[174] T. H. Luan, R. Lu, X. Shen, and F. Bai. "Social on the Road: Enabling Secure and Efficient Social Networking on Highways". In: *IEEE Wireless Communications* 22.1 (Feb. 2015), pp. 44–51. DOI: 10.1109/MWC.2015.7054718.

[175] E. Luo, Q. Liu, J. H. Abawajy, and G. Wang. "Privacy-Preserving Multi-Hop Profile-Matching Protocol for Proximity Mobile Social Networks". In: *Future Generation Computer Systems* 68 (Mar. 2017), pp. 222–233. DOI: 10.1016/j.future.2016.09.013.

[176] Z. A. Lux, F. Beierle, S. Zickau, and S. Göndör. "Full-Text Search for Verifiable Credential Metadata on Distributed Ledgers". In: *Proc. 2019 Sixth International Conference on Internet of Things: Systems, Management and Security (IOTSMS)*. IEEE, Oct. 2019, pp. 519–528. DOI: 10.1109/IOTSMS48152.2019.8939249.

[177] Z. A. Lux, D. Thatmann, S. Zickau, and F. Beierle. "Distributed-Ledger-Based Authentication with Decentralized Identifiers and Verifiable Credentials". In: *2020 2nd Conference on Blockchain Research Applications for Innovative Networks and Services (BRAINS)*. IEEE, Sept. 2020, pp. 71–78. DOI: 10.1109/BRAINS49436.2020.9223292.

[178] M. Mani, Anh-Minh Nguyen, and N. Crespi. "SCOPE: A Prototype for Spontaneous P2P Social Networking". In: *2010 8th IEEE International Conference on Pervasive Computing and Communications Workshops (PERCOM Workshops)*. Mar. 2010, pp. 220–225. DOI: 10.1109/PERCOMW.2010.5470664.

[179] J. Manweiler, R. Scudellari, and L. P. Cox. "SMILE: Encounter-Based Trust for Mobile Social Services". In: *Proceedings of the 16th ACM Conference on Computer and Communications Security*. ACM, 2009, pp. 246–255.

[180] Z. Mao, Y. Jiang, G. Min, S. Leng, X. Jin, and K. Yang. "Mobile Social Networks: Design Requirements, Architecture, and State-of-the-Art Technology". In: *Computer Communications* 100.Supplement C (Mar. 2017), pp. 1–19. DOI: 10.1016/j.comcom.2016.11.006.

[181] Z. Mao, J. Ma, Y. Jiang, and B. Yao. "Performance Evaluation of WiFi Direct for Data Dissemination in Mobile Social Networks". In: *2017 IEEE Symposium on Computers and Communications (ISCC)*. IEEE, July 2017, pp. 1213–1218. DOI: 10.1109/ISCC.2017.8024690.

[182] A. Markowetz, K. Błaszkiewicz, C. Montag, C. Switala, and T. E. Schlaepfer. "Psycho-Informatics: Big Data Shaping Modern Psychometrics". In: *Medical Hypotheses* 82.4 (Apr. 2014), pp. 405–411. DOI: 10.1016/j.mehy.2013.11.030.

[183] D. M. Marvin. "Occupational Propinquity as a Factor in Marriage Selection". In: *Quarterly Publications of the American Statistical Association* 16.123 (Sept. 1918), pp. 131–150. DOI: 10.1080/15225445.1918.10503750.

[184] S. C. Matz, M. Kosinski, G. Nave, and D. J. Stillwell. "Psychological Targeting as an Effective Approach to Digital Mass Persuasion". In: *Proceedings of the National Academy of Sciences* 114.48 (Nov. 2017), pp. 12714–12719. DOI: 10.1073/pnas.1710966114.

[185] J. Mayer. "Is There a Place for Serendipitous Introductions?" In: *Proceedings of the Companion Publication of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing*. CSCW Companion '14. ACM, 2014, pp. 73–76. DOI: 10.1145/2556420.2556827.

[186] J. Mayer and Q. Jones. "Encount'r: Exploring Passive Context-Awareness for Opportunistic Social Matching". In: *Proceedings of the 19th ACM Conference on Computer Supported Cooperative Work and Social Computing Companion*. CSCW '16 Companion. ACM, 2016, pp. 349–352. DOI: 10.1145/2818052.2869080.

[187] J. M. Mayer, S. R. Hiltz, L. Barkhuus, K. Väänänen, and Q. Jones. "Supporting Opportunities for Context-Aware Social Matching: An Experience Sampling Study". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. Association for Computing Machinery, May 2016, pp. 2430–2441. DOI: 10.1145/2858036.2858175.

[188] J. M. Mayer, S. R. Hiltz, and Q. Jones. "Making Social Matching Context-Aware: Design Concepts and Open Challenges". In: ACM Press, 2015, pp. 545–554. DOI: 10.1145/2702123.2702343.

[189] J. M. Mayer, Q. Jones, and S. R. Hiltz. "Identifying Opportunities for Valuable Encounters: Toward Context-Aware Social Matching Systems". In: *ACM Trans. Inf. Syst.* 34.1 (July 2015), 1:1–1:32. DOI: 10.1145/2751557.

[190] J. M. Mayer, S. Motahari, R. P. Schuler, and Q. Jones. "Common Attributes in an Unusual Context: Predicting the Desirability of a Social Match". In: *Proceedings of the Fourth ACM Conference on Recommender Systems*. RecSys '10. ACM, 2010, pp. 337–340. DOI: 10.1145/1864708.1864781.

[191] R. R. McCrae. "Social Consequences of Experiential Openness". In: *Psychological Bulletin* 120.3 (Nov. 1996), pp. 323–337. DOI: 10.1037/0033-2909.120.3.323.

[192] R. R. McCrae and O. P. John. "An Introduction to the Five-Factor Model and Its Applications". In: *Journal of Personality* 60.2 (1992), pp. 175–215.

[193] B. McMahan, E. Moore, D. Ramage, S. Hampson, and B. A. y Arcas. "Communication-Efficient Learning of Deep Networks from Decentralized Data". In: *Proceedings of the 20th International Conference on Artificial Intelligence and Statistics*. Ed. by A. Singh and J. Zhu. Vol. 54. Proceedings of Machine Learning Research. PMLR, 2017, pp. 1273–1282.

[194] M. McPherson, L. Smith-Lovin, and J. M. Cook. "Birds of a Feather: Homophily in Social Networks". In: *Annual Review of Sociology* 27 (2001), pp. 415–444.

[195] A. Mehrotra, R. Hendley, and M. Musolesi. "Towards Multi-Modal Anticipatory Monitoring of Depressive States through the Analysis of Human-Smartphone Interaction". In: *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct*. UbiComp '16. Association for Computing Machinery, Sept. 2016, pp. 1132–1138. DOI: 10.1145/2968219.2968299.

[196] A. Mehrotra, F. Tsapeli, R. Hendley, and M. Musolesi. "MyTraces: Investigating Correlation and Causation between Users' Emotional States and Mobile Phone Interaction". In: *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 1.3 (Sept. 2017), 83:1–83:21. DOI: 10.1145/3130948.

[197] A. Mei, G. Morabito, P. Santi, and J. Stefa. "Social-Aware Stateless Forwarding in Pocket Switched Networks". In: *2011 Proceedings IEEE INFOCOM*. Apr. 2011, pp. 251–255. DOI: 10.1109/INFCOM.2011.5935076.

[198] A. Mei, G. Morabito, P. Santi, and J. Stefa. "Social-Aware Stateless Routing in Pocket Switched Networks". In: *IEEE Transactions on Parallel and Distributed Systems* 26.1 (Jan. 2015), pp. 252–261. DOI: 10.1109/TPDS.2014.2307857.

[199] C. Mettouris and G. A. Papadopoulos. "Ubiquitous Recommender Systems". In: *Computing* 96.3 (Mar. 2014), pp. 223–257. DOI: 10.1007/s00607-013-0351-z.

[200] Michael J. Roche, Aaron L. Pincus, Amanda L. Rebar, David E. Conroy, and Nilam Ram. "Enriching Psychological Assessment Using a Person-Specific Analysis of Interpersonal Processes in Daily Life". In: *Assessment* 21.5 (Oct. 2014), pp. 515–528. DOI: 10.1177/1073191114540320.

[201] B. N. Miller, I. Albert, S. K. Lam, J. A. Konstan, and J. Riedl. "MovieLens Unplugged: Experiences with a Recommender System on Four Mobile Devices". In: *People and Computers XVII — Designing for Society*. Ed. by E. O'Neill, P. Palanque, and P. Johnson. Springer, 2004, pp. 263–279. DOI: 10.1007/978-1-4471-3754-2_16.

[202] G. Miller. "The Smartphone Psychology Manifesto". In: *Perspectives on Psychological Science* 7.3 (May 2012), pp. 221–237. DOI: 10.1177/1745691612441215.

[203] E. Miluzzo, N. D. Lane, K. Fodor, R. Peterson, H. Lu, M. Musolesi, S. B. Eisenman, X. Zheng, and A. T. Campbell. "Sensing Meets Mobile Social Networks: The Design, Implementation and Evaluation of the CenceMe Application". In: *Proceedings of the 6th ACM Conference on Embedded Network Sensor Systems*. SenSys '08. ACM, 2008, pp. 337–350. DOI: 10.1145/1460412.1460445.

[204] M. Mohajireen, C. Ellepola, M. Perera, I. Kahanda, and U. Kanewala. "Relational Similarity Model for Suggesting Friends in Online Social Networks". In: *Proc. 2011 6th International Conference on Industrial and Information Systems (ICIIS)*. IEEE, Aug. 2011, pp. 334–339. DOI: 10.1109/ICIINFS.2011.6038090.

[205] D. C. Mohr, M. Zhang, and S. M. Schueller. "Personal Sensing: Understanding Mental Health Using Ubiquitous Sensors and Machine Learning". In: *Annual*

Review of Clinical Psychology 13 (May 2017), pp. 23–47. DOI: 10.1146/annurev-clinpsy-032816-044949.

[206] B. Mønsted, A. Mollgaard, and J. Mathiesen. "Phone-Based Metric as a Predictor for Basic Personality Traits". In: *Journal of Research in Personality* 74 (June 2018), pp. 16–22. DOI: 10.1016/j.jrp.2017.12.004.

[207] C. Montag, H. Baumeister, C. Kannen, R. Sariyska, E.-M. Meßner, and M. Brand. "Concept, Possibilities and Pilot-Testing of a New Smartphone Application for the Social and Life Sciences to Study Human Behavior Including Validation Data from Personality Psychology". In: *J — Multidisciplinary Scientific Journal* 2.2 (June 2019), pp. 102–115. DOI: 10.3390/j2020008.

[208] C. Montag, K. Błaszkiewicz, B. Lachmann, I. Andone, R. Sariyska, B. Trendafilov, M. Reuter, and A. Markowetz. "Correlating Personality and Actual Phone Usage". In: *Journal of Individual Differences* 35.3 (Jan. 2014), pp. 158–165. DOI: 10.1027/1614-0001/a000139.

[209] C. Montag, K. Błaszkiewicz, R. Sariyska, B. Lachmann, I. Andone, B. Trendafilov, M. Eibes, and A. Markowetz. "Smartphone Usage in the 21st Century: Who Is Active on WhatsApp?" In: *BMC Research Notes* 8.1 (Aug. 2015), p. 331. DOI: 10.1186/s13104-015-1280-z.

[210] C. Montag, É. Duke, and A. Markowetz. "Toward Psychoinformatics: Computer Science Meets Psychology". In: *Computational and Mathematical Methods in Medicine* 2016 (2016), pp. 1–10. DOI: 10.1155/2016/2983685.

[211] J. Müller, C. Anneser, M. Sandstede, L. Rieger, A. Alhomssi, F. Schwarzmeier, B. Bittner, I. Aslan, and E. André. "Honeypot: A Socializing App to Promote Train Commuters' Wellbeing". In: *Proceedings of the 17th International Conference on Mobile and Ubiquitous Multimedia*. MUM 2018. ACM, 2018, pp. 103–108. DOI: 10.1145/3282894.3282901.

[212] S. D. Myers, S. Sen, and A. Alexandrov. "The Moderating Effect of Personality Traits on Attitudes toward Advertisements: A Contingency Framework". In: *Management & Marketing* 5.3 (2010), pp. 3–20.

[213] S. Nakagawa, P. C. D. Johnson, and H. Schielzeth. "The Coefficient of Determination R2 and Intra-Class Correlation Coefficient from Generalized Linear Mixed-Effects Models Revisited and Expanded". In: *Journal of the Royal Society, Interface* 14.134 (Sept. 2017). DOI: 10.1098/rsif.2017.0213.

[214] S. Nakagawa and H. Schielzeth. "A General and Simple Method for Obtaining R2 from Generalized Linear Mixed-Effects Models". In: *Methods in Ecology and Evolution* 4.2 (2013), pp. 133–142. DOI: 10.1111/j.2041-210x.2012.00261.x.

[215] C. Nass and K. M. Lee. "Does Computer-Generated Speech Manifest Personality? An Experimental Test of Similarity-Attraction". In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI '00. Association for Computing Machinery, Apr. 2000, pp. 329–336. DOI: 10.1145/332040.332452.

[216] N. d. A. B. Navarro, C. A. da Costa, J. L. V. Barbosa, and R. d. R. Righi. "Spontaneous Social Network: Toward Dynamic Virtual Communities Based on Context-Aware Computing". In: *Expert Systems with Applications* 95 (Apr. 2018), pp. 72–87. DOI: 10.1016/j.eswa.2017.11.017.

[217] T. H. Nguyen, D. Q. Tran, G. M. Dam, and M. H. Nguyen. "Estimating the Similarity of Social Network Users Based on Behaviors". In: *Vietnam Journal of Computer Science* 5.2 (May 2018), pp. 165–175. DOI: 10.1007/s40595-018-0112-1.

[218] G. S. Njoo, K.-W. Hsu, and W.-C. Peng. "Distinguishing Friends from Strangers in Location-Based Social Networks Using Co-Location". In: *Pervasive and Mobile Computing* 50 (Oct. 2018), pp. 114–123. DOI: 10.1016/j.pmcj.2018.09.001.

[219] T. Oide, T. Abe, and T. Suganuma. "Infrastructure-Less Communication Platform for Off-The-Shelf Android Smartphones". In: *Sensors* 18.3 (Mar. 2018), p. 776. DOI: 10.3390/s18030776.

[220] D. J. Ozer and V. Benet-Martínez. "Personality and the Prediction of Consequential Outcomes". In: *Annual Review of Psychology* 57.1 (Nov. 2005), pp. 401–421. DOI: 10.1146/annurev.psych.57.102904.190127.

[221] C. Parkinson, A. M. Kleinbaum, and T. Wheatley. "Similar Neural Responses Predict Friendship". In: *Nature Communications* 9.1 (Jan. 2018), pp. 1–14. DOI: 10.1038/s41467-017-02722-7.

[222] T. Paul, A. Famulari, and T. Strufe. "A Survey on Decentralized Online Social Networks". In: *Computer Networks* 75, Part A (Dec. 2014), pp. 437–452. DOI: 10.1016/j.comnet.2014.10.005.

[223] J. G. Phillips, S. Butt, and A. Blaszczynski. "Personality and Self-Reported Use of Mobile Phones for Games". In: *CyberPsychology & Behavior* 9.6 (Dec. 2006), pp. 753–758. DOI: 10.1089/cpb.2006.9.753.

[224] A.-K. Pietiläinen, E. Oliver, J. LeBrun, G. Varghese, and C. Diot. "MobiClique: Middleware for Mobile Social Networking". In: *Proceedings of the 2Nd ACM Workshop on Online Social Networks*. WOSN '09. ACM, 2009, pp. 49–54. DOI: 10.1145/1592665.1592678.

[225] J. S. Pokorski. *TYDR Fusion: Ubiquitous Social Networking Based on Automatically Tracked Data*. Bachelor's Thesis. Technische Universität Berlin. 2019.

[226] R. Pryss, D. John, M. Reichert, B. Hoppenstedt, L. Schmid, W. Schlee, M. Spiliopoulou, J. Schobel, R. Kraft, M. Schickler, B. Langguth, and T. Probst. "Machine Learning Findings on Geospatial Data of Users from the TrackYourStress mHealth Crowdsensing Platform". In: *2019 IEEE 20th International Conference on Information Reuse and Integration for Data Science (IRI)*. July 2019, pp. 350–355. DOI: 10.1109/IRI.2019.00061.

[227] R. Pryss, T. Probst, W. Schlee, J. Schobel, B. Langguth, P. Neff, M. Spiliopoulou, and M. Reichert. "Prospective Crowdsensing versus Retrospective Ratings of Tinnitus Variability and Tinnitus–Stress Associations Based on the TrackYourTinnitus Mobile Platform". In: *International Journal of Data Science and Analytics* 8.4 (Nov. 2019), pp. 327–338. DOI: 10.1007/s41060-018-0111-4.

[228] R. Pryss, T. Probst, W. Schlee, J. Schobel, B. Langguth, P. Neff, M. Spiliopoulou, and M. Reichert. "Prospective Crowdsensing versus Retrospective Ratings of Tinnitus Variability and Tinnitus–Stress Associations Based on the

TrackYourTinnitus Mobile Platform". In: *International Journal of Data Science and Analytics* 8.4 (Nov. 2019), pp. 327–338. DOI: 10.1007/s41060-018-0111-4.

[229] R. Pryss, M. Reichert, B. Langguth, and W. Schlee. "Mobile Crowd Sensing Services for Tinnitus Assessment, Therapy, and Research". In: *Mobile Services (MS), 2015 IEEE International Conference On*. IEEE, 2015, pp. 352–359. DOI: 10.1109/MobServ.2015.55.

[230] X. Qiao, W. Yu, J. Zhang, W. Tan, J. Su, W. Xu, and J. Chen. "Recommending Nearby Strangers Instantly Based on Similar Check-In Behaviors". In: *IEEE Transactions on Automation Science and Engineering* 12.3 (July 2015), pp. 1114–1124. DOI: 10.1109/TASE.2014.2369429.

[231] K. K. Rachuri, M. Musolesi, C. Mascolo, P. J. Rentfrow, C. Longworth, and A. Aucinas. "EmotionSense: A Mobile Phones Based Adaptive Platform for Experimental Social Psychology Research". In: *Proceedings of the 12th ACM International Conference on Ubiquitous Computing*. UbiComp '10. ACM, 2010, pp. 281–290. DOI: 10.1145/1864349.1864393.

[232] D. Rawlings and V. Ciancarelli. "Music Preference and the Five-Factor Model of the NEO Personality Inventory". In: *Psychology of Music* 25.2 (Oct. 1997), pp. 120–132. DOI: 10.1177/0305735697252003.

[233] *Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the Protection of Natural Persons with Regard to the Processing of Personal Data and on the Free Movement of Such Data, and Repealing Directive 95/46/EC (General Data Protection Regulation) (Text with EEA Relevance)*. May 2016.

[234] P. J. Rentfrow and S. D. Gosling. "The Do Re Mi's of Everyday Life: The Structure and Personality Correlates of Music Preferences." In: *Journal of Personality and Social Psychology* 84.6 (2003), pp. 1236–1256. DOI: 10.1037/0022-3514.84.6.1236.

[235] A. Richter and M. Koch. "Functions of Social Networking Services". In: *Proc. 8th International Conference on the Design of Cooperative Systems (COOP '08)*. May 2008, pp. 87–98.

[236] J. Rodrigues, E. R. B. Marques, L. M. B. Lopes, and F. Silva. "Towards a Middleware for Mobile Edge-Cloud Applications". In: *Proceedings of the 2Nd Workshop on Middleware for Edge Clouds & Cloudlets*. MECC '17. ACM, 2017, 1:1–1:6. DOI: 10.1145/3152360.3152361.

[237] S. Rodriguez Garzon and B. Deva. "Geofencing 2.0: Taking Location-Based Notifications to the Next Level". In: *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing*. UbiComp '14. ACM, 2014, pp. 921–932. DOI: 10.1145/2632048.2636093.

[238] V. A. Rohani and O. S. Hock. "On Social Network Web Sites: Definition, Features, Architectures and Analysis Tools". In: *Journal of Computer Engineering* 1 (2009), pp. 3–11.

[239] J. Rooksby, A. Morrison, and D. Murray-Rust. "Student Perspectives on Digital Phenotyping: The Acceptability of Using Smartphone Data to Assess Mental Health". In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. CHI '19. ACM, 2019, 425:1–425:14. DOI: 10.1145/3290605.3300655.

[240] S. Rothmann and E. P. Coetzer. "The Big Five Personality Dimensions and Job Performance". In: *SA Journal of Industrial Psychology* 29.1 (Oct. 2003). DOI: 10.4102/sajip.v29i1.88.

[241] G. Ruffo and R. Schifanella. "A Peer-to-Peer Recommender System Based on Spontaneous Affinities". In: *ACM Transactions on Internet Technology* 9.1 (Feb. 2009), pp. 1–34. DOI: 10.1145/1462159.1462163.

[242] S. Saeb, M. Zhang, C. J. Karr, S. M. Schueller, M. E. Corden, K. P. Kording, and D. C. Mohr. "Mobile Phone Sensor Correlates of Depressive Symptom Severity in Daily-Life Behavior: An Exploratory Study". In: *Journal of Medical Internet Research* 17.7 (July 2015), e175. DOI: 10.2196/jmir.4273.

[243] D. Saha and A. Mukherjee. "Pervasive Computing: A Paradigm for the 21st Century". In: *Computer* 36.3 (Mar. 2003), pp. 25–31. DOI: 10.1109/MC.2003.1185214.

[244] P. Sapiezynski, A. Stopczynski, D. K. Wind, J. Leskovec, and S. Lehmann. "Offline Behaviors of Online Friends". In: *arXiv:1811.03153 [cs]* (Nov. 2018). arXiv: 1811.03153 [cs].

[245] A. Sapuppo. "Spiderweb: A Social Mobile Network". In: *2010 European Wireless Conference (EW)*. Apr. 2010, pp. 475–481. DOI: 10.1109/EW.2010.5483495.

[246] A. Sapuppo and T. Sørensen. "Local Social Networks". In: *Computer Communication and Management: International Proceedings of Computer Science and Information Technology*. Vol. 5. IACSIT Press, 2011, pp. 15–22.

[247] M. Schedl, G. Breitschopf, and B. Ionescu. "Mobile Music Genius: Reggae at the Beach, Metal on a Friday Night?" In: *Proceedings of International Conference on Multimedia Retrieval*. ACM, 2014, pp. 507–510.

[248] T. J. Scheff. *Microsociology: Discourse, Emotion, and Social Structure*. University of Chicago Press, 1990.

[249] R. Schnell, T. Bachteler, and J. Reiher. "Privacy-Preserving Record Linkage Using Bloom Filters". In: *BMC Medical Informatics and Decision Making* 9.1 (Aug. 2009), p. 41. DOI: 10.1186/1472-6947-9-41.

[250] R. Schoedel, Q. Au, S. T. Völkel, F. Lehmann, D. Becker, M. Bühner, B. Bischl, H. Hussmann, and C. Stachl. "Digital Footprints of Sensation Seeking". In: *Zeitschrift für Psychologie* 226.4 (Oct. 2018), pp. 232–245. DOI: 10.1027/2151-2604/a000342.

[251] D. Schuster, A. Rosi, M. Mamei, T. Springer, M. Endler, and F. Zambonelli. "Pervasive Social Context: Taxonomy and Survey". In: *ACM Trans. Intell. Syst. Technol.* 4.3 (July 2013), 46:1–46:22. DOI: 10.1145/2483669.2483679.

[252] A. Seifert, M. Hofer, and M. Allemand. "Mobile Data Collection: Smart, but Not (Yet) Smart Enough". In: *Frontiers in Neuroscience* 12 (2018). DOI: 10.3389/fnins.2018.00971.

[253] M. Selfhout, W. Burk, S. Branje, J. Denissen, M. Van Aken, and W. Meeus. "Emerging Late Adolescent Friendship Networks and Big Five Personality Traits: A Social Network Approach". In: *Journal of Personality* 78.2 (Apr. 2010), pp. 509–538. DOI: 10.1111/j.1467-6494.2010.00625.x.

[254] Y. Shafranovich. "Bluetooth Data Exchange Between Android Phones Without Pairing". In: *arXiv:1507.00650 [cs]* (Apr. 2016). arXiv: 1507.00650 [cs].

[255] R. S. Sharma. "Clothing Behaviour, Personality, and Values: A Correlational Study". In: *Psychological Studies* 25.2 (1980), pp. 137–142.

[256] J. Shu, S. Kosta, R. Zheng, and P. Hui. "Talk2Me: A Framework for Device-to-Device Augmented Reality Social Network". In: *2018 IEEE International Conference on Pervasive Computing and Communications (PerCom)*. IEEE, Mar. 2018, pp. 1–10. DOI: 10.1109/PERCOM.2018.8444578.

[257] E. Siira and V. Törmänen. "The Impact of NFC on Multimodal Social Media Application". In: *2010 Second International Workshop on Near Field Communication*. Apr. 2010, pp. 51–56. DOI: 10.1109/NFC.2010.16.

[258] A. Sikora, M. Krzysztoń, and M. Marks. "Application of Bluetooth Low Energy Protocol for Communication in Mobile Networks". In: *2018 International Conference on Military Communications and Information Systems (ICMCIS)*. May 2018, pp. 1–6. DOI: 10.1109/ICMCIS.2018.8398689.

[259] V. K. Singh and R. R. Agarwal. "Cooperative Phoneotypes: Exploring Phone-Based Behavioral Markers of Cooperation". In: *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing*. UbiComp '16. ACM, Sept. 2016, pp. 646–657. DOI: 10.1145/2971648.2971755.

[260] V. K. Singh and I. Ghosh. "Inferring Individual Social Capital Automatically via Phone Logs". In: *Proceedings of the ACM on Human-Computer Interaction* 1.CSCW (Dec. 2017), 95:1–95:12. DOI: 10.1145/3134730.

[261] C. J. Soto and O. P. John. "The next Big Five Inventory (BFI-2): Developing and Assessing a Hierarchical Model with 15 Facets to Enhance Bandwidth, Fidelity, and Predictive Power." In: *Journal of Personality and Social Psychology* 113.1 (2017), pp. 117–143. DOI: 10.1037/pspp0000096.

[262] R. Staake. *Social Profile Exchanges in Proximity-based Mobile Social Networks*. Bachelor's Thesis. Technische Universität Berlin. 2018.

[263] C. Stachl, Q. Au, R. Schoedel, D. Buschek, S. Völkel, T. Schuwerk, M. Oldemeier, T. Ullmann, H. Hussmann, B. Bischl, and M. Bühner. *Behavioral Patterns in Smartphone Usage Predict Big Five Personality Traits*. Preprint. PsyArXiv, June 2019. DOI: 10.31234/osf.io/ks4vd.

[264] C. Stachl, S. Hilbert, J.-Q. Au, D. Buschek, A. De Luca, B. Bischl, H. Hussmann, and M. Bühner. "Personality Traits Predict Smartphone Usage". In: *European Journal of Personality* 31.6 (Nov. 2017), pp. 701–722. DOI: 10.1002/per.2113.

[265] H. Stead and P. A. Bibby. "Personality, Fear of Missing out and Problematic Internet Use and Their Relationship to Subjective Well-Being". In: *Computers in Human Behavior* 76 (Nov. 2017), pp. 534–540. DOI: 10.1016/j.chb.2017.08.016.

[266] A. A. Stone and S. Shiffman. "Ecological Momentary Assessment (EMA) in Behavioral Medicine". In: *Annals of Behavioral Medicine* 16.3 (Jan. 1994), pp. 199–202. DOI: 10.1093/abm/16.3.199.

[267] T. Stütz, T. Kowar, M. Kager, M. Tiefengrabner, M. Stuppner, J. Blechert, F. H. Wilhelm, and S. Ginzinger. "Smartphone Based Stress Prediction". In: *User Modeling, Adaptation and Personalization*. Ed. by F. Ricci, K. Bontcheva, O. Conlan, and S. Lawless. Lecture Notes in Computer Science. Springer International Publishing, 2015, pp. 240–251. DOI: 10.1007/978-3-319-20267-9_20.

[268] B. Sun, Q. Ma, S. Zhang, K. Liu, and Y. Liu. "iSelf: Towards Cold-Start Emotion Labeling Using Transfer Learning with Smartphones". In: *ACM Transactions on Sensor Networks* 13.4 (Sept. 2017), 30:1–30:22. DOI: 10.1145/3121049.

[269] J. Teng, B. Zhang, X. Li, X. Bai, and D. Xuan. "E-Shadow: Lubricating Social Interaction Using Mobile Phones". In: *2011 31st International Conference on Distributed Computing Systems*. June 2011, pp. 909–918. DOI: 10.1109/ICDCS.2011.48.

[270] J. Teng, B. Zhang, X. Li, X. Bai, and D. Xuan. "E-Shadow: Lubricating Social Interaction Using Mobile Phones". In: *IEEE Transactions on Computers* 63.6 (June 2014), pp. 1422–1433. DOI: 10.1109/TC.2012.290.

[271] Y.-C. Teng, Y.-S. Kuo, and Y.-H. Yang. "A Large In-Situ Dataset for Context-Aware Music Recommendation on Smartphones". In: *2013 IEEE International Conference on Multimedia and Expo Workshops (ICMEW)*. July 2013, pp. 1–4. DOI: 10.1109/ICMEW.2013.6618254.

[272] Y.-C. Teng, Y.-S. Kuo, and Y.-H. Yang. "A Large In-Situ Dataset for Context-Aware Music Recommendation on Smartphones". In: *2013 IEEE International Conference on Multimedia and Expo Workshops (ICMEW)*. July 2013, pp. 1–4. DOI: 10.1109/ICMEW.2013.6618254.

[273] L. Terveen and D. W. McDonald. "Social Matching: A Framework and Research Agenda". In: *ACM Transactions on Computer-Human Interaction (TOCHI)* 12.3 (Sept. 2005), pp. 401–434. DOI: 10.1145/1096737.1096740.

[274] M. Thelwall. "Chapter 2 Social Network Sites: Users and Uses". In: *Advances in Computers*. Vol. 76. Social Networking and The Web. Elsevier, Jan. 2009, pp. 19–73. DOI: 10.1016/S0065-2458(09)01002-X.

[275] E. R. Thompson. "Development and Validation of an International English Big-Five Mini-Markers". In: *Personality and Individual Differences* 45.6 (Oct. 2008), pp. 542–548. DOI: 10.1016/j.paid.2008.06.013.

[276] J. Tillmanns. "Privately Computing Set-Union and Set-Intersection Cardinality via Bloom Filters". In: *Information Security and Privacy: 20th Australasian Conference, ACISP 2015, Brisbane, QLD, Australia, June 29–July 1, 2015, Proceedings*. Vol. 9144. Springer, 2015, pp. 413–430.

[277] S. Trifunovic, M. Kurant, K. A. Hummel, and F. Legendre. "WLAN-Opp: Ad-Hoc-Less Opportunistic Networking on Smartphones". In: *Ad Hoc Networks*. New Research Challenges in Mobile, Opportunistic and Delay-Tolerant Networks 25 (Feb. 2015), pp. 346–358. DOI: 10.1016/j.adhoc.2014.07.011.

[278] O. Turkes, H. Scholten, and P. J. M. Havinga. "Opportunistic Beacon Networks: Information Dissemination via Wireless Network Identifiers". In: *2016 IEEE International Conference on Pervasive Computing and Communication Workshops (PerCom Workshops)*. Mar. 2016, pp. 1–6. DOI: 10.1109/PERCOMW.2016.7457153.

[279] D. Wang, D. Pedreschi, C. Song, F. Giannotti, and A.-L. Barabasi. "Human Mobility, Social Ties, and Link Prediction". In: *Proceedings of the 17th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining - KDD '11*. ACM Press, 2011, p. 1100. DOI: 10.1145/2020408.2020581.

[280] R. Wang, F. Chen, Z. Chen, T. Li, G. Harari, S. Tignor, X. Zhou, D. Ben-Zeev, and A. T. Campbell. "StudentLife: Assessing Mental Health, Academic Performance and Behavioral Trends of College Students Using Smartphones". In: *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing*. UbiComp '14. ACM, 2014, pp. 3–14. DOI: 10.1145/2632048.2632054.

[281] R. Wang, F. Chen, Z. Chen, T. Li, G. Harari, S. Tignor, X. Zhou, D. Ben-Zeev, and A. T. Campbell. "StudentLife: Using Smartphones to Assess Mental Health and Academic Performance of College Students". In: *Mobile Health*. Springer, Cham, 2017, pp. 7–33. DOI: 10.1007/978-3-319-51394-2_2.

[282] R. Wang, G. Harari, P. Hao, X. Zhou, and A. T. Campbell. "SmartGPA: How Smartphones Can Assess and Predict Academic Performance of College Students". In: *Proc. 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp 2015)*. ACM, Sept. 2015, pp. 295–306. DOI: 10.1145/2750858.2804251.

[283] W. Wang, G. M. Harari, R. Wang, S. R. Müller, S. Mirjafari, K. Masaba, and A. T. Campbell. "Sensing Behavioral Change over Time: Using Within-Person Variability Features from Mobile Sensing to Predict Personality Traits". In: *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 2.3 (Sept. 2018), 141:1–141:21. DOI: 10.1145/3264951.

[284] X. Wang, H. Wang, K. Li, S. Yang, and T. Jiang. "Serendipity of Sharing: Large-Scale Measurement and Analytics for Device-to-Device (D2D) Content Sharing in Mobile Social Networks". In: *2017 14th Annual IEEE International Conference on Sensing, Communication, and Networking (SECON)*. June 2017, pp. 1–9. DOI: 10.1109/SAHCN.2017.7964925.

[285] Y. Wang, A. V. Vasilakos, Q. Jin, and J. Ma. "Survey on Mobile Social Networking in Proximity (MSNP): Approaches, Challenges and Architecture". In: *Wireless Networks* 20.6 (Aug. 2014), pp. 1295–1311. DOI: 10.1007/s11276-013-0677-7.

[286] Y. Wang, L. Wei, Q. Jin, and J. Ma. "AllJoyn Based Direct Proximity Service Development: Overview and Prototype". In: *2014 IEEE 17th International Conference on Computational Science and Engineering*. Dec. 2014, pp. 634–641. DOI: 10.1109/CSE.2014.138.

[287] M. Weiser. "The Computer for the 21st Century". In: *Scientific American* 265.3 (1991), pp. 94–104. DOI: 10.1038/scientificamerican0991-94.

[288] P. Welke, I. Andone, K. Blaszkiewicz, and A. Markowetz. "Differentiating Smartphone Users by App Usage". In: *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing*. UbiComp '16. ACM, 2016, pp. 519–523. DOI: 10.1145/2971648.2971707.

[289] P. Wilcox, S. Winn, and M. Fyvie-Gauld. "'It Was Nothing to Do with the University, It Was Just the People': The Role of Social Support in the First-year Experience of Higher Education". In: *Studies in Higher Education* 30.6 (Dec. 2005), pp. 707–722. DOI: 10.1080/03075070500340036.

[290] C. Wilson, T. Steinbauer, G. Wang, A. Sala, H. Zheng, and B. Y. Zhao. "Privacy, Availability and Economics in the Polaris Mobile Social Network". In: *Proceedings of the 12th Workshop on Mobile Computing Systems and Applications*. HotMobile '11. ACM, 2011, pp. 42–47. DOI: 10.1145/2184489.2184499.

[291] F. Xia, N. Y. Asabere, H. Liu, Z. Chen, and W. Wang. "Socially Aware Conference Participant Recommendation With Personality Traits". In: *IEEE Systems Journal* 11.4 (Dec. 2017), pp. 2255–2266. DOI: 10.1109/JSYST.2014.2342375.

[292] H. Xiong, Y. Huang, L. E. Barnes, and M. S. Gerber. "Sensus: A Cross-Platform, General-Purpose System for Mobile Crowdsensing in Human-Subject Studies". In: *Proc. 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp 2016)*. UbiComp '16. ACM, Sept. 2016, pp. 415–426. DOI: 10.1145/2971648.2971711.

[293] R. Xu, R. M. Frey, E. Fleisch, and A. Ilic. "Understanding the Impact of Personality Traits on Mobile App Adoption – Insights from a Large-Scale Field Study". In: *Computers in Human Behavior* 62.Supplement C (Sept. 2016), pp. 244–256. DOI: 10.1016/j.chb.2016.04.011.

[294] J. Yang, C. Poellabauer, P. Mitra, J. Rao, and C. Neubecker. "BlueNet: BLE-Based Ad-Hoc Communications without Predefined Roles". In: *2017 IEEE SmartWorld, Ubiquitous Intelligence Computing, Advanced Trusted Computed, Scalable Computing Communications, Cloud Big Data Computing, Internet of People and Smart City Innovation (SmartWorld/SCALCOM/UIC/ATC/CBDCom/IOP/SCI)*. IEEE, Aug. 2017, pp. 1–8. DOI: 10.1109/UIC-ATC.2017.8397434.

[295] W.-S. Yang and S.-Y. Hwang. "iTravel: A Recommender System in Mobile Peer-to-Peer Environment". In: *Journal of Systems and Software* 86.1 (Jan. 2013), pp. 12–20. DOI: 10.1016/j.jss.2012.06.041.

[296] Z. Yang, B. Zhang, J. Dai, A. Champion, D. Xuan, and D. Li. "E-SmallTalker: A Distributed Mobile System for Social Networking in Physical Proximity". In: *2010 IEEE 30th International Conference on Distributed Computing Systems (ICDCS)*. IEEE, June 2010, pp. 468–477. DOI: 10.1109/ICDCS.2010.56.

[297] T. Yarkoni. "Psychoinformatics: New Horizons at the Interface of the Psychological and Computing Sciences". In: *Current Directions in Psychological Science* 21.6 (Dec. 2012), pp. 391–397. DOI: 10.1177/0963721412457362.

[298] Z. Yin, M. Gupta, T. Weninger, and J. Han. "A Unified Framework for Link Recommendation Using Random Walks". In: *Proc. 2010 International Conference on Advances in Social Networks Analysis and Mining (ASONAM)*. IEEE, Aug. 2010, pp. 152–159. DOI: 10.1109/ASONAM.2010.27.

[299] S. Yogesh, S. Abha, and S. Priyanka. "Mobile Usage and Sleep Patterns among Medical Students". In: *Indian J Physiol Pharmacol* 58.1 (2014), pp. 100–103.

[300] Z. Yu, Y. Liang, B. Xu, Y. Yang, and B. Guo. "Towards a Smart Campus with Mobile Social Networking". In: *2011 International Conference on Internet*

of Things and 4th International Conference on Cyber, Physical and Social Computing. Oct. 2011, pp. 162–169. DOI: 10.1109/iThings/CPSCom.2011.55.

[301] O. Yurur, C. Liu, Z. Sheng, V. Leung, W. Moreno, and K. Leung. "Context-Awareness for Mobile Sensing: A Survey and Future Directions". In: *IEEE Communications Surveys Tutorials* 18.1 (2014), pp. 1–28. DOI: 10.1109/COMST.2014.2381246.

[302] R. B. Zajonc. "Attitudinal Effects of Mere Exposure". In: *Journal of Personality and Social Psychology* 9.2, Pt.2 (1968), pp. 1–27. DOI: 10.1037/h0025848.

[303] W. Zhang, H. Flores, and P. Hui. "Towards Collaborative Multi-Device Computing". In: *2018 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops)*. IEEE, Mar. 2018, pp. 22–27. DOI: 10.1109/PERCOMW.2018.8480262.

[304] X. Zhang, W. Li, X. Chen, and S. Lu. "MoodExplorer: Towards Compound Emotion Detection via Smartphone Sensing". In: *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 1.4 (Jan. 2018), 176:1–176:30. DOI: 10.1145/3161414.

[305] X. Zhang, F. Zhuang, W. Li, H. Ying, H. Xiong, and S. Lu. "Inferring Mood Instability via Smartphone Sensing: A Multi-View Learning Approach". In: *Proceedings of the 27th ACM International Conference on Multimedia*. MM '19. Association for Computing Machinery, Oct. 2019, pp. 1401–1409. DOI: 10.1145/3343031.3350957.

[306] T. Zhou and Y. Lu. "The Effects of Personality Traits on User Acceptance of Mobile Commerce". In: *International Journal of Human–Computer Interaction* 27.6 (June 2011), pp. 545–561. DOI: 10.1080/10447318.2011.555298.

[307] S. Zickau, F. Beierle, and I. Denisow. "Securing Mobile Cloud Data with Personalized Attribute-Based Meta Information". In: *Proc. 3rd IEEE International Conference on Mobile Cloud Computing, Services, and Engineering (MobileCloud)*. IEEE, Mar. 2015, pp. 205–210. DOI: 10.1109/MobileCloud.2015.14.

[308] C.-N. Ziegler. “Semantic Web Recommender Systems”. In: *Current Trends in Database Technology - EDBT 2004 Workshops*. Ed. by W. Lindner, M. Mesiti, C. Türker, Y. Tzitzikas, and A. I. Vakali. Lecture Notes in Computer Science. Springer, 2005, pp. 78–89.

[309] E. Zielinski, J. Schulz-Zander, M. Zimmermann, C. Schellenberger, A. Ramirez, F. Zeiger, M. Mormul, F. Hetzelt, F. Beierle, H. Klaus, H. Ruckstuhl, and A. Artemenko. “Secure Real-Time Communication and Computing Infrastructure for Industry 4.0 — Challenges and Opportunities”. In: *Proc. 2019 International Conference on Networked Systems (NetSys)*. IEEE, Mar. 2019, pp. 1–6. DOI: 10.1109/NetSys.2019.8854499.

[310] J. Zimmermann, W. C. Woods, S. Ritter, M. Happel, O. Masuhr, U. Jaeger, C. Spitzer, and A. G. C. Wright. “Integrating Structure and Dynamics in Personality Assessment: First Steps toward the Development and Validation of a Personality Dynamics Diary”. In: *Psychological Assessment* 31.4 (2019), pp. 516–531. DOI: 10.1037/pas0000625.

Citing this thesis

Find me at https://www.beierle.de and contact me at felix@beierle.de

Citation example:

F. Beierle. *Integrating Psychoinformatics with Ubiquitous Social Networking: Advanced Mobile-Sensing Concepts and Applications.* Springer, 2021. DOI: 10.1007/978-3-030-68840-0.

Bibtex:

```
@book{Beierle2021thesis,
title = {Integrating Psychoinformatics with Ubiquitous Social Networking:
Advanced Mobile-Sensing Concepts and Applications},
author = {Beierle, Felix},
year = {2021},
publisher = {Springer},
doi = {10.1007/978-3-030-68840-0},
series = {{T-Labs Series in Telecommunication Services}}
}
```