



 University of St.Gallen

ETH zürich



Auto-ID Labs ETH/HSG
Year in Review
2016



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Director's Note

Dear colleagues and friends,

On behalf of all our lab members, I'm delighted to share with you a few highlights of the research conducted at the Swiss Auto-ID Labs in the past year.

Our interdisciplinary team focused on the consumer side of the Internet of Things. While most consumers are continuously connected to the Internet, the retail industry is still at the beginning of its digital transformation. Today, we are only seeing the tip of the iceberg with consumers scanning barcodes in stores and thereby unknowingly get in touch with a GS1 system originally created to make businesses more efficient.

To be at the forefront of what will shape and influence the next five to ten years of GS1 standards, we conduct research in close collaboration with leading industry players and tech start-ups. We love to build things and evaluate new technologies in the wild. As you will see on the next few pages, our work includes a wide range of topics from mobile self-checkout, to product-related services, to reality-mining, to secure data sharing, to mobile health and nutritional literacy.

We believe that when ideas are shared, they become bigger. Therefore, we publish our results in leading academic conferences & journals, maintain close relations to the other Auto-ID Labs, attend GS1 events, support the labs' annual Internet of Things conference and engage in Europe's largest hackathon.

It is exciting to see the GS1 community's open spirit of innovation. Thank you for letting us be a part of this journey!



Alexander Ilic

Director Auto-ID Labs ETH/HSG



Lab Members



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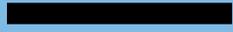
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Project Reports

Mobile Self-Checkout

A Novel Solution for Fast-Paced Convenience Retail



Denis Vuckovac
Ph.D. candidate and
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In December 2016 Amazon presented its effort to bring checkout-less shopping to physical retailing, Amazon Go. We have developed our mobile self-checkout implementation, Scan&Go, in March 2016 and launched the first iteration of our public pilot at three retail outlets of Swiss kiosk and convenience retailer Valora in June the same year. Since then and with only little marketing effort, more than 70 recruited users have made at least one purchase with the app. And in fact, more than half of these are recurring customers that regularly use the app – a number way above the industry average illustrating great benefit of such a mobile self-checkout solution.

Decreasing purchasing times

We have implemented our app for probably one of the most demanding settings in Europe: Switzerland has one of the highest share of commuters, mostly by train, and as a matter of fact convenience stores and kiosks at transit stations usually exhibit huge spikes in the morning and afternoon. It is during these periods of the day that consumers are most time constrained as they often need to catch a connecting train or bus. However, during these times queues are the longest. Thus, we have

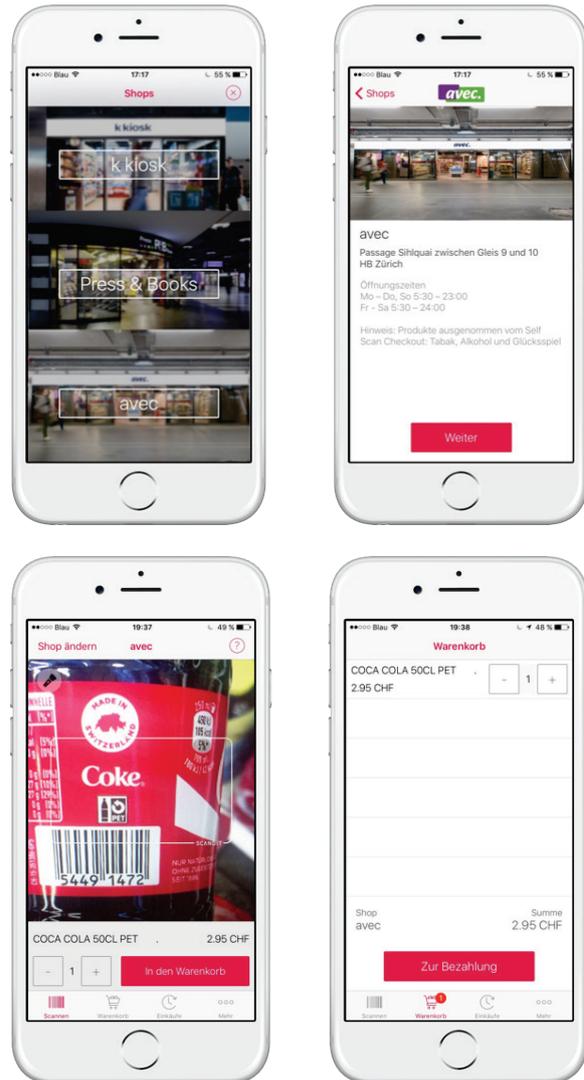


Figure 1: Mobile Self-Checkout app Scan&Go: 1) Check-In Screen, 2) Store Overview, 3) Scan View, 4) Basket Overview.

designed a mobile self-checkout application with the specific goal to minimize checkout times. And we have shown during our 6-month pilot that during peak times app users are on average about 60 seconds faster compared to regular customers. Furthermore, whether stores are packed or not,

Scan&Go users can purchase their coffee, soft drink or snack in about 30 seconds. And while first time users usually need a bit more time, experienced users can make a purchase in less than 20 seconds.

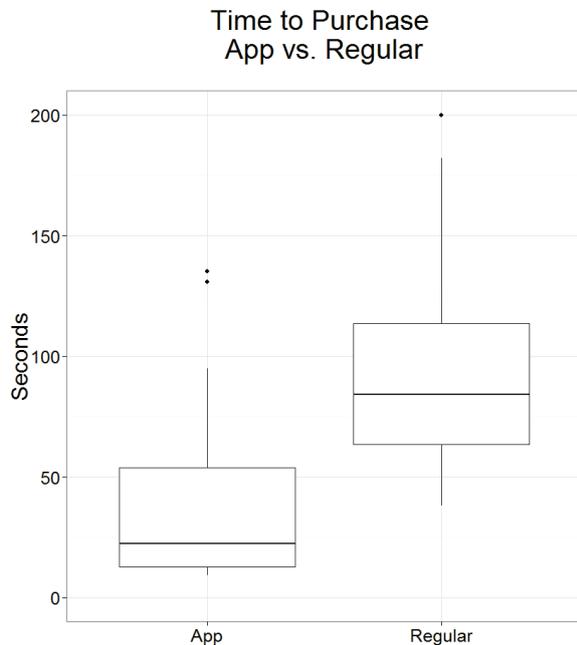


Figure 2: Comparison of average purchasing times for regular shoppers and app users during peak hours.

Harnessing regular purchasing patterns

For retailers without any existing loyalty system such an app offers the unique opportunity to link transactions and thus gain valuable insights into individual purchasing patterns. One of our first findings is that while we usually see equally big peaks in the morning and afternoon periods, users of our self-checkout app are mostly making purchases in the morning but not when they are heading home in the afternoon. Getting these users to make purchases in the afternoon too is a big use case that can only be unlocked through such an app which for the first time offers the retailer the opportunity to approach customers individually and in a scalable way.

Supporting adoption and preventing retail shrinkage

Early on in our pilot we have realized that unlike new technologies that are privately consumed, public information systems such as our mobile

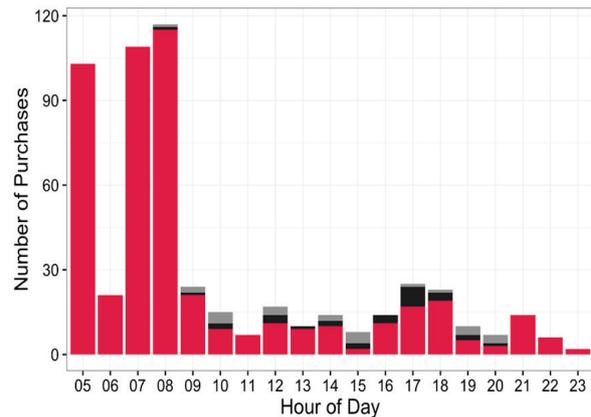


Figure 3: Distribution of transactions throughout the day.

self-checkout system require additional public feedback channels. This allows signaling successful purchases to everyone and thus distinguishing between proper self-checkout users and potential shop lifters. We hypothesize that the correct signaling is important for first time users to not feel uncomfortable and thus supports adoption. We plan to further investigate the underlying psychologic mechanisms of our public feedback solution and furthermore aim to analyze whether the mobile self-checkout pilot had an impact on actual retail shrinkage rates.

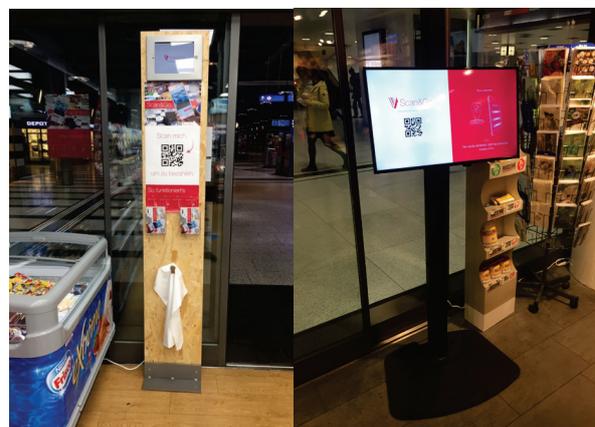


Figure 4: First (left) and second generation of our public feedback implementation (right).

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Proximity-Based Services

Product-Related Services and VR/AR



Dr. Runhua Xu
Post-doctoral researcher

The trend of providing services in addition to selling products starts in the manufacturing industry, where the room for product differentiation is limited but services provide another revenue stream for companies to stay competitive. With the increasing ubiquity and connectivity of smartphones and new devices like augmented reality (AR), it becomes for the first time technologically and economically feasible for companies to offer services directly to end-consumers in a B2C setting. In my research, I aim to leverage auto-IDs and new technologies to connect manufacturers directly with consumers by enabling physical products as digital service end-points.

Enabling physical products as digital service end-points [1]

With the paradigm of the Internet of Things, the Internet extends to the physical world. Products can be enhanced with digital service offerings. A first generation of solutions already exists around QR codes and iBeacons to identify products and to provide consumers with services through their own mobile phones. As an alternative to fully connected "smart products", manufactures and

service providers can use tags to enhance their existing products with service offerings. Amazon has received wild success with their Dash product and Google's Physical Web shows how proximity interactions can work. However, these solutions are not scalable, focus on a single service, and require high effort. In addition, current Bluetooth based solutions overwhelm users with their push notifications – thus making it impossible for a deployment with multiple products and multiple users.

1) Scanning a barcode



2) Proximity-based notifications



3) Press a physical button



4) Combine physical with digital world in augmented reality



Figure 1. The evolution of how a consumer can interact with a physical product for digital services.

With new augmented reality devices like Microsoft HoloLens, it becomes more natural for consumers to combine the physical and digital world. Consequently, we developed a HoloLens

demo to research how physical products can be turned into digital service end-points in the future. Services about a product only pop-up when consumers gaze at the product or make an air-tap, thereby solving the information overload problem. On the other hand, product can be recognized at a serial level based on image recognition and proximity-based technologies like Bluetooth beacons.

Understanding personal differences in mobile service adoption [2]

Smartphones are the most personal devices people own and carry around with them all day. The number of available mobile apps in major app stores now easily exceeds one million – providing an app for almost any situation of our life. Consequently, the kind of apps people install and use could be closely linked to their interest, demographics, and personality. Due to the fact that 98% of the Fortune 500 companies have already started to offer services through mobile apps, we are thus motivated to understand how personality traits influence an individual's decision on adopting different mobile services.

We developed a mobile gaming app called personality test (as shown in Figure 2) to collect data about each smartphone user's personality traits as well as her app installation and update logs. The app is listed on Google Play Store and more than 2000 smartphone users used the app. In total, we analyzed 63,688 mobile apps and found that personality traits have a significant impact on the adoption of mobile services and such an impact is strongly dependent on the type of the service. Based on the type of a new mobile app, managers will know who are more likely to become adopters of the app thereby improving their marketing effectiveness.

Automatic user profiling [3]

Although personality traits are proved to be important in enhancing consumers' adoption of mobile services, an individual's personality

remains unknown until being measured by lengthy survey, which is costly and not scalable. As a result, we propose a scalable machine-learning approach to predict personality traits with information like app installation and update events that are openly accessible to all app developers. The precision of our model is 65% higher than a random guess. Additionally, the model can be deployed in a non-intrusive, low privacy-concern, and highly scalable manner as part of any mobile app. In addition to service

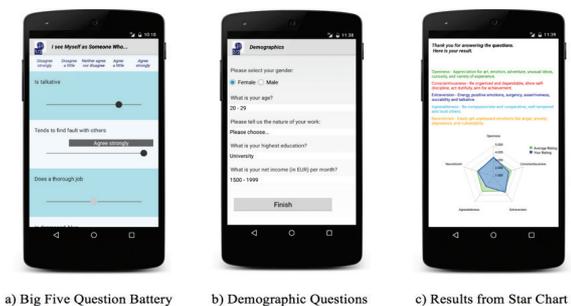


Figure 2. Screenshots of the Personality Test app.

adoption, research in other fields shows that personality traits influence people's decision on product choice, purchasing behavior, store selection, brand loyalty, reaction to marketing campaigns, etc. By combining such findings with our models, firms can conduct better market segmentation and targeting, to improve customer relationship management, to enhance customer brand loyalty, as well as to cross-sell other products and services to potential adopters in their mobile apps.

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Reality Mining on Smartphones

Mobile Personalization and Privacy-Preserving Recommender Systems



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Recognizing Differences in Consumers [1,2]

Consumers differ in a number of meaningful ways. Two of them are conceptualized in 'life events' and 'life stages'. Life events and life stages are often described as major forces that are going to shape tomorrow's consumer need, behavior and mood. Thus, its prediction is highly relevant in marketing and sociology. It is useful to detect events like getting married or starting a new job in order to improve customer services or to conduct more effective personalized promotions. Today, firms proactively approach their customers through surveys, emails, phone calls, advertising, or face-to-face interviews to inquire about current life stage or upcoming life events – which is time-consuming and not scalable. Due to the nature of events, they are very rare and thus it is nearly impossible to detect them in a timely manner with the present methods.

We proposed to use the list of installed apps to get real-time insights about individual life events and life stages. We constantly install, update, or delete apps on our devices to match our personal

needs – thus making this data stream valuable for reality mining. Figure 1 shows a schematic view of the process to generate personalized content (e.g. advertising, recommendations, news articles, and offers). First, an app (marked by the star icon) sends data about all the other apps on a user's mobile device via Internet to a service or content provider. Then, based on these data, the provider sends personalized services or content back to the user.

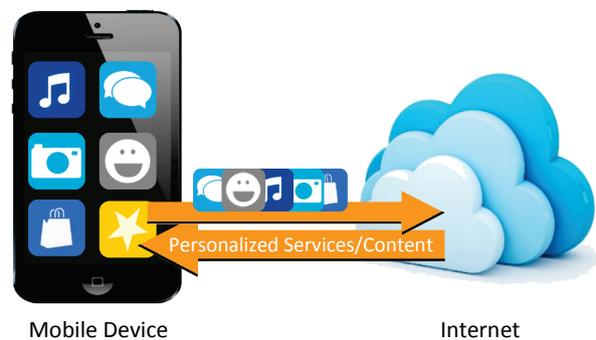


Figure 1. Schematic view of the investigated process.

We developed an Android app, which is described as a personality test game, where users can find out more about their personality and their life. Figure 2 shows two screenshots of the app. If a user accepts the privacy policy, a background process is initiated, which reads app installation logs from the device and sends it to a backend webserver. The user can choose between several personality tests. Each test is shortly explained and contains a questionnaire (Figure 2a). The result is illustrated by a spider graph (Figure 2b). It is the only user incentive.

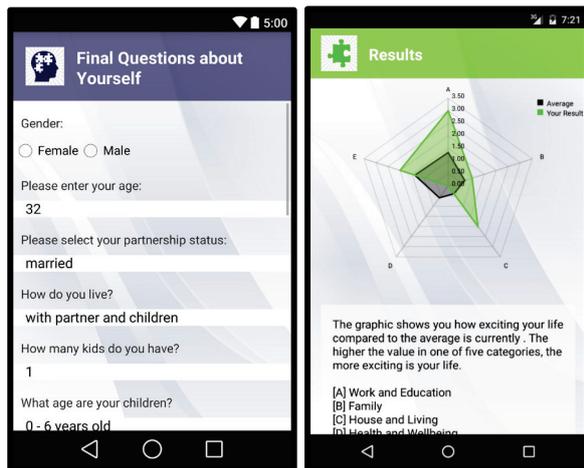


Figure 2. Screenshots: (a) questionnaire, (b) results.

In a first study, we focused on the prediction of life events [1], as reported in the lab review 2015. One year later, we explored life stages [2] and conducted a second empirical study with 1435 participants. We demonstrated that a person's mobile app adoption pattern is strongly influenced by her current life stage. Further, we presented a data-driven, highly scalable, and real-time approach of predicting an individual's current life stage based on the apps she has installed on smartphone. Result showed that our predictive models were able to predict life stages with 241.0% higher precision and 148.2% higher recall than a random guess on average.

Collaborative Filtering on the Blockchain: A Secure Recommender System [3,4]

Today, recommender systems are everywhere in people's daily life and support them to make decisions in time. Especially in e-commerce, a reliable and efficient recommender system is essential. Vendors quickly realized the power and the importance for their own business. Over the last two decades, the usage of such systems changed from a trial balloon to a serious business tool. There is an increasing expectation of user-tailored recommendations, often referred to as mass personalization. Several marketing studies proved that personalization improves the revenue thereby the satisfaction of the customers increases. As a consequence, companies are creating detailed user profiles for

a better understanding of customer behavior, needs, and habits. Unfortunately, privacy concerns prevent users from sharing data generously with interested companies, even if the quality of the recommendations would be improved. They mainly fear fraud and misuse of their data and a loss of control. A novel blockchain-based approach ('Enigma' by Zyskind et al. 2015) is able to cryptographically guarantee the proper usage of personal data. The core component is a decentralized peer-to-peer network that allows storing encrypted data in a tamper-proof way and runs secure computations while no one but the data owner has access to the raw data. We propose to implement that approach in recommender systems. In doing so, a potential customer is able to allow a company to apply a recommendation algorithm without disclosing her profile. She never loses control of her data and is able to terminate the business relationship at any time. Fraud and misuse is no longer possible, because the involved company never gets the raw data. We speculate that such a system could become a standard for future recommender systems. We explained the interaction between customer, company, and system in two articles [3,4].

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Food Literacy and Healthy Nutrition



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Limited Effectiveness of Nutritional Education

Nutrition-related diseases are an alarming issue all over the world: In 2014 over 600 million adults and 42 million children were affected by obesity with growth rates of epidemic proportions [1]. Still, due to lack of financial resources, only a small part of society is reached through conventional measures such as education campaigns and nutritional coaching provided by physicians and dietitians. Upcoming, scalable Health information systems (HIS) have potential to overcome these limitations, but suffer under low end-user acceptance and interaction rates. Further, their current focus lies in rather abstract behavioral recommendations, which the end user cannot translate into health-beneficial real-world choices.

Recent Regulation

Regulators are introducing new laws to support consumers in making healthy food choices through recently ratified legislation such as EU1169/2014 (Online declaration of nutritional ingredients) and EU GDPR/2018 (Data Privacy Regulation), allowing users to share their loyalty card logs with health applications. In order to research how product master and digital receipt data sets can be leveraged to mitigate nutrition related diseases, we work with strategic partners, incl. Swiss Federal Office of Public Health, Swiss Federal Food Safety and Veterinary Office, Swiss

Society for Nutrition, Swiss health insurance and retail partners, GS1 Switzerland.

FoodQuiz – Gamification for Nutritional Literacy

“Swiss Foodquiz” was inspired by the world’s most played educational trivia game Quizup, adapted to asking users to conduct a visual examination task requiring nutritional knowledge. The user task simulates choosing products at the supermarket shelf, as the user has to choose the one out of two similar, visually presented food products with the higher content of a relevant given nutrient, e.g. identifying the product with significantly lower amounts of salt compared to its substitutable alternative. With the approach, which has been published [2], it can be shown that the extension of serious game principles to nutritional education can increase nutritional literacy and overcome low acceptance rates among average, uninvolved and unhealthy users.

SaltTracker – Digital Receipts & Diet Monitoring

“Swiss SaltTracker” is a multi-stage project in which users log their diet through a validated Food Record Checklist. Further they share their loyalty card information including digital receipts of the past two years with the app. SaltTracker then computes a nutritional assessment for the user’s diet and purchases, suggesting product alternatives with lower sodium content. The research question behind is threefold: First, proving that digital Food Records correlate with current dietary monitoring practices, e.g. bio-sampling or paper-based recalls. Second, developing machine learning models that automatically deduce a valid classification of a user’s salt intake behavior from digital receipts to enable scalable dietary monitoring. Third, testing effectiveness of tailored interventions to

convince users to reduce salt intake through personalized product recommendations.

Barcode Poster – Allergy Compatibility Number

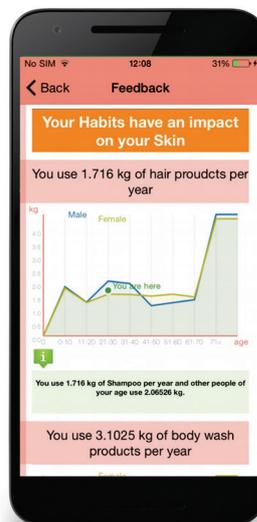
Besides macronutrients, also allergens are included public product master databases and can be retrieved to build helpful applications for restaurant visitors and supermarket consumers. Therefore, we propose a new allergy identifying standard that works across countries and organizations such that any meal's or product's compatibility with a user's allergy profile can be computed instantly. The approach has been published and received a best poster award at the IOT Conference 2016 in Stuttgart [4].

SkinProtect – Data for Exposure Assessment

The EU1169-regulation only enforces online declaration of food items, but it is expected that also beauty and healthcare items are to be declared in public online databases. SkinProtect is a research app, that allows users to scan their household products and answer questions to their usage patterns, i.e. frequency and quantity. The app then calculates the exposure to certain ingredients responsible for skin rashes.

Conclusion and Outlook

Our research exemplifies that automatic HIS can indeed address the current health challenges by leveraging product master data and digital receipts, thereby achieving quantifiable gains in nutritional education, allowing for dietary monitoring and effective tailored interventions. Especially since the majority of app users are currently uninvolved in health, and therefore unlikely to be reached by other contemporary interventions, such HIS offer promising potential of enrolling the previously uninvolved and uninterested users and to eventually change their attitude, involvement and behavior in regards to healthy behavior[3]. As democratizing knowledge and interventions are key elements of prevention, such scalable HIS can become a vital part of effective healthy strategies.



Research apps: 1) Foodquiz, 2) SaltTracker, 3) SkinProtect, 4) Food Allergy Check.

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HackZurich 2016

Retail Innovation Workshop

Hackathons are one- to three-day non-stop programming competitions and are becoming a new, viral phenomenon all over the world. The increasing number of hackathons not only includes small, regional events, but also large-scale competitions, such as NASA's "Space Apps Challenge" which attracts > 8,000 developers in multiple locations at the same time. So, we at Auto-ID Labs thought that it is time that GS1 joins the hackathon mania and starts working together with mobile developers to create new, innovative apps that might become "the next big thing" in the retail. Therefore, we partnered with Swiss retailers to host "Internet of Things in Retail Innovation Workshop" at HackZurich, Europe's largest hackathon.



Hackathons as Ground for Innovation

What is a Hackathon? Hackathons are programming events that usually take place over a 24h-, 40h-, 48h- or even 72h-time window and gather tech enthusiasts, e.g. app developers, software engineers, data scientists, creative designers, etc. to come up with creative, new, innovative software and/or hardware based solutions to a challenge. Hackathons have proven to be a true incubator for many ideas that turned into world-famous internet companies, e.g. Twitter. Therefore, more and more companies and organizations are sponsoring hackathons to collaborate openly together with developers to create applications on top of their infrastructure which might become valuable projects in the future.

Success Story: 44 Retail Apps in GS1's Track

GS1 and Auto-ID Labs joined forces with Swiss retailers Migros and Valora to host the "Retail Innovation Workshop" at HackZurich. In total, 1'455 developers participated in 2014 through 2016 combined, developing a total of more than 360 applications (See Table). Within our workshops, a total of 44 retail applications were developed at HackZurich.

	2014	2015	2016
Programmers	340	550	565
Retailer	Migros	Valora	Valora
Total Apps	101	123	ca. 140
Retail Apps	15	10	19



Notable apps were 1) mobile Self Checkout which allows shoppers to use their own device to scan items at the shelf, pay within the app and not having to queue in line at the POS any more (Valora is actively realizing the mobile SelfCheckout), 2) Swiss Foodquiz, which is a viral educational serious game teaching Swiss app users about nutrition, based on GS1 Source

(Trustbox), has been downloaded >1000 times now and received positive PR in the media, and 3) Check&Out, which identifies customers to using facial recognition, and lets them quickly check out using a bar code scanner from the same app without having to queue.

Why should GS1 engage at more hackathons?

Hackathons are ideal opportunities for GS1 to collaborate with young developers. Furthermore, hackathons are nowadays a vital part of the developer community, which often is not yet familiar with the world of GS1 standards. In order to become more relevant in the digital space and spread awareness of standards, GS1 and its members should definitely keep an eye on upcoming hackathons.

<http://www.autoidlabs.ch>