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Domain and requirements for a wearable-based doping control system

In Germany, over 7000 professional athletes from different sport sectors must undergo regular doping controls. As is the case with many other nations, Germany relies upon a system recommended by the World Anti-Doping Agency (WADA) to coordinate and initiate these controls. Known as the Anti-Doping Admission and Administration System, or ADAMS for short, the system requires athletes to submit their future regular whereabouts via browser, up to three months in advance. This allows the Doping Control Officer (DCO) to be able to locate the athlete without prior notice. The flip side, however, is that, since its introduction in 2007, ADAMS has not only been severely criticized by athletes themselves for its lack of usability, but has also come under attack by data-privacy experts accusing this system of breaching multiple data privacy laws.

The PARADISE project – which stands for Privacy-Enhancing and Reliable Anti-Doping Integrated Service Environment – was conceived as a response to ADAMS' shortcomings. The project is a multidisciplinary endeavor that seeks to promote and guarantee the overall privacy, security, and usability of the anti-doping coordination platform. PARADISE was engendered in 2012, when Jonas Plass, a former 400m runner and German national track and field team member, came up with the idea of developing an additional system, called "EVES", to complement "ADAMS". Instead of expecting athletes to comply with otherwise unrealistic self-reporting months in advance, EVES would utilize location-based services to locate athletes' whereabouts. Mr. Plass and Dr. Denis Giffeler (gekko mbH) thus devised a fully detailed concept, which would materialize into a research project, PARADISE, comprising expertise and solutions from a wide array of fields.

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1 Stakeholders

Doping control systems (DCS) are used both by people (i.e., athletes and doping control officers) and by organizational entities (doping control authorities, laboratories that carry out urine/blood tests, etc.). In general, the requirements of person-stakeholders are very different from those of organization-stakeholders, because the latter need to deal with the provision, maintenance, and other related legal aspects of the DCS. Broadly speaking, these stakeholders interact more often than not with only one facet or interface of the DCS, but the system must nevertheless be optimized for all of them. Additional stakeholders, such as data protection and regulatory agencies, for example, define the constraints within which the system must work even though they in fact rarely use the system, if at all. Aside from this, sport organizations and nations comprise a different class of stakeholders, one for whom strict doping controls would seem to be in their best interests. Still, recent events have shown that this assumption may not hold true and that these stakeholders may have strong incentives towards lax or nonexistent controls.

From the beginning, the PARADISE project focused on initiating an athlete's doping control while guaranteeing, at the same time, usability, privacy, and data protection. Other tasks and processes currently implemented in ADAMS – for example, the management of laboratory results – were out of scope for the project. This is why only the stakeholders involved in initiating doping controls are listed below; laboratories and other out-of-scope participants are intentionally left out of the discussion in this article. Still, even within the constraints set forth by the project it-self, it is hard to have the expectations, opinions, and concerns of involved stakeholders overlap; and so, contradictory or antagonist views and needs are generally the norm.

1.1 Athletes

Doping is subject to Sociology's so-called "Prisoners' Dilemma,"[1]whereby two rational individuals might choose not to cooperate with each other even though doing so may seem to be in their best interests. When it comes to doping, athletes may not want to take illegal substances or use methods otherwise harmful to their health. Still, athletes do not know what other competitors in the same situation will do. Will competitors play according to the rules? To avoid a potential disadvantage, athletes assume that their competitors will not[2]. And so, just as in the prisoners' dilemma, pursuing individual reward leads athletes to the worst outcome possible: doping. This is why a doping control system is a must. The tricky aspect, however, has to do with how the DCS brings together adversarial parties that do not trust each other. A successful doping control system can only properly function on the premise of trust, on the generalized belief that the same rules and standards will apply to all institutions and competitors. This assumption amounts, as well, to the expectations, concerns, and needs of the athletes.

In general, athletes are willing to comply with almost anything required of them within the current system, as long as their competitors undergo the same routines. This said, there is absolutely no reason to abuse or overtax an athlete's willingness to 'play by the rules' by further complicating the system and disregarding usability or privacy aspects – sometimes in blatant opposition to the law. A technologically up-to-date system that lessens the load on the athletes while respecting their privacy and the law could go a long way in favor of the overall effectiveness of doping control. For this is ultimately what a good DCS is supposed to do: to work for the protection of clean athletes.

1.2 NADO/WADA

The World Anti-Doping Agency (WADA) was set up in November 1999 to harmonize international anti-doping efforts and thus make the entire anti-doping system as effective and efficient as possible. The international standards set by WADA were meant to guarantee equal opportunity for all athletes regardless of nationality. The 'code' passed by WADA every two years (WADAC) *recommends* the usage of ADAMS to manage doping control activities. Any other system *must* first be approved by WADA . As one of its core functionalities, any system used must allow for unannounced out-of-competition controls. To this end, and within the highest test-pool, a daily one-hour window of guaranteed availability must be reported by all athletes. Outside that window, and whenever an athlete is not in the exact reported location, the DCO will issue a phone call to make sure the athlete is not in the vicinity of the reported place, and organize a meeting with her/him within one hour. Should that be impossible, the doping control is then labeled as a 'missed test'. Three missed tests are equivalent to a positive doping result.

1.3 Doping Control Officers and Service Providers

In several nations, National Anti-Doping Agencies (NADO) do not employ their own doping control officers, but instead, outsource the task to so-called doping control providers. This is the case in Germany, for example. Most DCOs usually work on a part-time basis. The number of controls per month per DCO varies from less than five to 100. Both DCOs and service providers thus ask for as much information about an athlete's daily routines as possible; this helps service providers plan and assign the controls to specific DCOs, and helps DCOs plan their journey to an athlete's location. Therefore, detailed and correct whereabouts' information ensures quick doping controls where no time, resources, and also money, is wasted.

2 Key findings and lessons learned in field-testing

During the course of PARADISE, the so-called PARADISE platform was developed consisting mainly of two elements: an interface with which DCOs can plan their journeys and check an athlete's whereabouts, and a wearable for athletes to carry, which reports their location whenever an authorized DCO requests it. The platform takes care of any privacy and data protection issues, as noted in the »Wearables und Datenschutz« article in this publication. In July 2017, the platform was subject to field-testing to analyze the system's overall process and also to explore users' interaction with the system. The DCO interface was tested with five DCOs from one of the associated partners of the project (Professional Worldwide Controls, PWC), while the project's team internally tested wearable prototypes.

Testing was conducted separately with each participant. Tests began with a series of open-ended questions collected in earlier stages of the project's development and related to overall requirement analysis. Down the road, DCOs received a short introduction about PARADISE, the project, and about its platform, with plenty of hands-on examples on a tablet PC. During the main part of the field-testing, DCOs were asked to go through a real control scenario. Beginning with the reception and acceptance of a control order, DCOS then had to search for the selected athlete[3] and achieve the final meet-up. Cues and instructions for the DCO were kept to a minimum for the duration of the field-testing.

Two general findings were observed after all field-tests had been conducted: 1) DCOs were not happy with ADAMS; and 2) they hoped for an additional tool, something akin to the localization-device add-on EVES, to provide them with data that could actually make their jobs easier. Paradoxically – if not unsurprisingly for system designers and privacy advocates – DCOs are by now very used to their current step-by-step process, where they have access to the entirety of an athlete's private and location data (both current and past). Hence, any changes, however much they may simplify the process and improve privacy, are met with reservation.

1 Bird & Wagner, 1997; Eber, 2008; Haugen, 2004.

2 Both history and the amounts of money associated with winning a prize suggest that the assumption is warranted. It is important, however, to emphasize that the largest amount of doping does not happen in order to have an advantage over others, but rather to avoid a potential disadvantage.

3 For this test, the athlete was a member of the research team that was carrying a wearable and waiting at a location unknown to the DCO.

The findings of field-testing include technical implementation aspects and also the process side of doping control.

2.1 Technical implementation aspects

- Unlike ADAMS, PARADISE is inherently designed as a mobile solution. DCOs may wish to use a navigation system in the car and not be forced to use a second device. PARADISE must thus be designed in such a way that it can either entirely replace a navigation system, or else, extend a navigation system with information necessary for doping control.
- DCOs want the ability to see more days than the actual time window for testing whenever they access an athlete's calendar. Indeed, activities from previous weeks can help detect regular activities on the part of an athlete that would otherwise not be supplied in the calendar for a given control window. Having access to one or two weeks in the future could also be helpful when asking for an extension of a given control window.
- Interface usability was almost optimal and needed minor improvements.

2.2 Process aspects

- To avoid unsuccessful control attempts, most DCOs only try athletes at so-called 'safe hours', i.e. time windows with supplied whereabouts. Those hours where no whereabouts are given are deemed 'too risky' and are generally avoided. This dynamic severely limits the effectiveness of the doping control system currently in place, further supporting the use of a location-based concept such as EVES.
- Using EVES in combination with PARADISE would open up the entire day to doping controls, while guaranteeing a higher likelihood of finding the athlete. Still, in order to protect athletes' privacy, DCOs would generally just be supplied with a position with an average accuracy of 250 meters – i.e. they would not be given the exact name and address where to ring at. In our field-testing, four out of five DCOs had to call the athlete. The meet-up was achieved within two minutes after the call, which is a very short time-frame when compared to the one-hour limit set by the WADAC. With ADAMS, DCOs are told to avoid phone calls whenever possible so as to not give any advanced warning to the selected athlete. The PARADISE approach, however, may require more phone calls, but it also dramatically shortens warning time. Responsible NADOs and WADA must thus decide what is more effective: more phone calls with an extremely short warning time, or fewer phone calls with up to an hour of advanced warning.
- That an athlete may change her/his location is a major concern for DCOs, because their standard approach (I'm navigating to a point where the athlete is very likely to be) does not work anymore with PARADISE. The PARADISE platform provides a continuously updated location, which in the eyes of the DCOs may seem as if s/he were chasing the athlete. Still, this new system gives athletes more freedom, allowing them to decide how they wish to use their time, no longer bound to a given location. In this regard, DCOs have admitted that, even in cases where they would know an athlete's exact location, they would most likely avoid instances such as when an athlete is in a residential block, because, used as they are to ADAMS exact address/name/location, they wouldn't know clearly where to ring and would be forced to call the athlete.

3 Risks and interferences for a wearable-based system

We reported earlier that trust is essential for a successful doping control system. Among the factors that influence trust, system security, resilience, and usability play a crucial role. Still, wearable devices used for tracking athletes in a doping control system face different risks and interferences, both willful and accidental. Left unattended, these can make a control system useless or otherwise open the door to denial of service attacks, impersonation attacks, or other failures. Indeed, even when the failure of a single wearable may not mean much for the DCS system as a whole, it may still impact the career and the future of the athlete carrying the wearable. During the design and development stages of PARADISE and other complex socio-technical systems,[4] various risks

4 *Badham/Clegg/Wall*, Socio-technical theory, in:Handbook of Ergonomics, New York, NY: John Wiley (2000); *Baxter/Sommerville*, Socio-technical Systems: From Design Methods to Systems Engineering, in: Interact. Comput. 23.1 (2011), pp. 4–17. issn: 0953-5438. doi:10.1016/j.intcom.2010.07.003. url: http://dx.doi.org/10.1016/j.intcom.2010.07.003.

and interference potentials were identified.[5] They can be grouped in four categories, as listed below:

- Risks and interferences from system users:
  - The wearable may be lost or destroyed, without the athlete even noticing it, resulting in unfair penalties for not being reachable.
  - The wearable may be used by an unintended user, such as another athlete, for example, in detriment of her/his rival.
- Risks and interferences from the environment:
  - Mobile components of the DCS may be used in all kinds of weather and environments where it is possible for humans to survive and train.
  - Mobile components of the DCS may be polluted by sweat, saliva, mud, dust, water, blood, and other pollutants associated with training activity.
  - Other devices present in the environment may cause radio or communication interference with the wearable and mobile components of the DCS.
  - The presence of multiple individuals with mobile phones in the vicinity of an athlete, e.g. a competition, may limit the cellular bandwidth available for that athlete's wearable.
  - Communications infrastructure may be inadequate, unavailable, or completely missing.
  - Pre-existing ICT infrastructure may be available but restricted, overloaded, or turned off, such as in underground and military locations.
  - GNSS signal coverage may be missing for long periods.
  - The legal landscape may change, causing the protections of personal information stored in the DCS to be removed, thus making it public or open to use for other purposes.
- Risks and interferences from third parties:
  - Wearables may be stolen or come into the possession of individuals who use them to infiltrate, circumvent the security of, or otherwise interfere with the DCS.
  - Third parties may actively tamper with DCS system components, either to destroy the system, or to destroy people's trust in the system.
  - Third parties may actively jam or interfere with the communications between DCS components.
  - Remote services used by the DCS, e.g. databases, address-lookup services, and messaging systems may become unavailable, overloaded, may deliver wrong results, or may suffer a security breach.
- Risks and interferences inherent to the system:
  - A wearable's communication protocols may enable others to track the movements of an athlete without needing to break, decrypt, or otherwise tamper with the DCS system.
  - The usability of the DCS system may be deficient, either for all athletes, or for handicapped, paraplegic, blind, and other special groups of athletes.
  - The electronics and/or batteries of the DCS's mobile components may fail or relay erroneous data.
  - The DCS may lack a secure way to update software, especially in mobile and wearable components.
  - The DCS may not be able to deal with changes in the doping control process or in the athletes' lifestyle.
  - The DCS may not be able to limit credibility breaches, such as when the security of one component has been breached and, as a result, it is impossible to prove the integrity of other components.
- Risks and interferences caused by the system upon other systems:
  - The wearable may interfere with the safety or security of other systems set in the environment where the athlete will be, such as airplanes, etc.
  - The system may inadvertently change the doping control process and negatively impact trust and social interaction between athletes and controllers.
  - The system may have unexpected legal and ethical implications or may be used by law enforcement and other entities for purposes other than doping control.

The impact and mitigation strategy against such risks must be defined and implemented as part of the system already before launch. The risks we identified are by no means the only ones, but they can serve as a starting point to raise awareness about explicit and proactive risk mitigation.

4 Conclusion

The current state of affairs and the systems used in doping control are unsustainable. Two of the core stakeholders, Athletes and DCOs are already dissatisfied, while privacy and data protection regulators accept the current DCS solely because, up till now, there has been no available alternative. DCOs unanimously support the idea of a minimally invasive localization feature, able to support them in their daily work. Athletes also welcome any approaches helping to protect their privacy and lighten the amount of work and interaction they must routinely contend with in dealing with the DCS. In this sense, the PARADISE project and PARADISE platform have been designed to respond to these aspects, presenting themselves as a solid potential solution to many of the shortcomings of the current doping-control system.

This said, a good system on its own is not enough. The process currently in place, though cumbersome, has been used for so long that it is already deeply engraved into the minds and habits of both athletes and DCOs. Hence, more effective and less complicated solutions may be initially greeted with doubt or wariness. So that, even when a new system can bring benefits to everyone involved, as reported in this article, there is an initial acceptance hurdle that cannot be conquered by rational argumentation alone. It is of the utmost importance for DCOs to see how these benefits play out 'in real life'. Supporters and early adopters are thus essential in helping with the introduction of the new system.

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5 *Elmasllari*, A framework for the successful design and deployment of electronic triage systems. PhD Thesis, RWTH Aachen, 2017.