Application for a new punching system for Trail orienteering "ToePunch" (Trail-o e-Punch)

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Preamble

Punching for trail orienteering is very specific and differs from all other disciplines in several key facts:

- At each station, the competitor must choose from several answers (A-E, Z). This can be done either using several punching devices (units, boxes), using several cards (chips) carried by competitors, or using a user interface of the device.
- Speed is not important since time is not subject to comparison when making results, so a competitor can spend a few seconds operating equipment at a punching station.

All this means that our system cannot be used for any other discipline and can be approved only for trail orienteering.

History

During several years of experiments, we tried different ways to solve the problem of punching in trail-o. The first usable solution was based on the principle of a set of SI units at punching stations. However, this brings great complications to the organizers and is relatively expensive. Another attempt was to use the ANT application as a user interface on mobile phones located at punching stations. This solution was successfully tested, for example, at an international competition in Slovenia in Spring 2020. An unpleasant complication of this approach is the need to guard the punching stations to prevent theft of phones. Another possibility is to lend competitors smartphones with ANT and let them carry them and punch on them.

Sami Hyvönen at Fin5 in 2019 tested another variant, where a competitor carries a set of NFC chips for different answers and uses a proper one for punching his/her answer. The advantage was a simpler but less clear punching, while the need to watch the phones remained. Our approach was to develop a new hardware device that can communicate with chips carried by competitors, store data in both repositories and transfer it to a server.

The system was tested in 2021 at four WRE events (together eight races) as a backup system:

- Rak TrailO, Slovenia, 55 competitors, Organiser: Krešo Keresteš, Ján Furucz
- TRaVilO, Finland, 66 competitors, Organiser: Janne Seppälä, Juha Hiirsalmi
- FinTrailO, Finland, 43 competitors, Organiser: Petteri Hakala
- Falco Cup, Lithuania, 68 competitors, Organiser: Andrius Jovaiša, Zita Rukšane

Short reports from these events are on http://toe.yq.cz.

Basic components

- Each punching station is equipped with a unit ("Toe box") which is the same size as the SportIdent box (so that the same sticks and holders can be used). This box is driven by organizers' and competitors' NFC chips, stores data both to the chips and to the internal memory of the box and transfers data (according to its configuration) to a server.

- Organizers configure the boxes by a special set of NFC chips (for event identification, event time slot definition, clock synchronization, box role and number etc.). These chips are configured by a mobile application.

- Competitors have a set of 7 chips (answers A-E, Z and Start/Finish/Info) which are used at the start, at the finish and for punching at a station. Competitors simply touch the appropriate chip to a unit (Clear, Start, Finish or Answer unit).

- Before the start, all chips in a competitors' set must be cleared (and configured for a new event) at a Clear box.

- No read-out is needed if the connection is good and data is transferred by WiFi directly from the units. However, using a mobile application for reading out the chips at a read-out point after the finish or in a CC was tested as a good option for transferring data to a result system.

- The components are relatively cheap, the boxes are cheaper than SI boxes, and a competitor chip set (7 chips) will probably cost less than 10 euros.

Operating principle

When a competitor touches an NFC chip to a toe-box, the box starts to communicate with the chip:

- It reads identification data from the chip and stores it in the memory of the box.
- It writes a box identification and time to the competitor's chip as a backup.
- A toe-box uploads data using a WiFi connection.
  - If it is placed in an area covered by a WiFi signal, it can send the data directly to a server on the Internet.
  - If no WiFi coverage is available, the transfer can be mediated by smartphones with a WiFi hotspot (carried by marshals or placed along the course) and mobile data connectivity.
  - If even a mobile data network is not available, the role of the server can be played by a smartphone with the ANT application (ant.yq.cz). The data is stored there and the smartphone can be then transported to a place with better connectivity.
  - If the competition is organized in an area without any kind of connectivity, the data can be downloaded to a PC or notebook and processed locally.

- There are several modes for uploading data:
    o After each competitor's punch.
    o Periodically, each 5, 10 or 15 minutes from the competition start time.
    o On demand – by touching a special Upload chip to the box.

Fulfillment of essential criteria

a) The system transfers data about punching to a server. Processing the data on a server is not a part of this application. Currently, at least the preoresultat.se server is compatible and able to present results. The data written to a competitor's chip can be read by a mobile application which shows the answers and times.

b) Before the start, a competitor should clear and check all chips by touching them to the Clear unit. The unit will display chip identification. Then, the competitor touches the Start/Finish/Info chip to the Start unit and his/her race is started.

c) Reaction time of Toe boxes is below 130 ms.

d) The unit acknowledges a successful communication with a chip by a beep, LED signal and message on the display. If any of these acknowledgements is received, the punch was successful.

e) For punching, touching the chip to the unit is needed.

f) The ToePunch system does not have touch-free punching.

g) Since the system is not touch-free, only one competitor can punch in the same moment. Repeated punching is possible. Competitors are fully responsible for selecting a proper chip and touching it to a proper unit.

h) There is a special Station Info chip; touching this chip to a Toe box causes the box to display configuration information and battery capacity.

i) The data about a competitor's race is stored on the server before the competitor comes to the finish. If the read-out point is used, the competitors' chips are read by a special mobile application and they can be checked immediately.

j) We don't know about any case of a missing punch despite successful acknowledgement given by a Toe box in any of the four WRE races where the system was tested.

k) We successfully tested the equipment in temperatures around 0 and +55 degrees Centigrade. We also tested it at -25 and +65 degrees, but only for a limited time (10 min heating/freezing and 20 min work at the max/min temperature).

l) There is no known common interference that would affect the proper operation of units.

m) There is a web page which will cover all information needs for organizers.

Fulfillment of other criteria

a) The times of all punches (with an accuracy of one second) are included in punching records.

b) Since the exact overall running time is not a result criteria in trail-o, the time is recorded with an absolute accuracy of one second only, for all units. The clock in units have an accuracy below 0.2 sec per 5 hours.

c) The chips are bound together and the bundle can be held, hung or put into a pocket. Competitors in trail-o do not cross thickets during the race.

d) The configuration of units is very easy (as it was tested at testing WRE races). The organizer has a set of Admin chips to configure boxes. However, most of the configuration (e.g. role and number of a box) is fixed for the whole lifetime of the box and only a few parameters (Event ID, time synchronization, WiFi parameters, result server etc.) have to be configured again before a new race. Admin chips for these operations are prepared in a mobile application and then touched to each unit to complete the setup.

e) The weight of the toe-box is less than 150 g.

f) The Toe box can be carried to a WiFi device (or vice versa) and forced to upload the data via WiFi. For the case of WiFi problems, the data from unit can be downloaded by NFC or USB.

g) We didn't make a special crash test but several boxes have already fallen from the height of a table and they still work normally. The outer box is made by 3D printing and according to our experience under "normal" behavior the box is robust enough.

h) Classic punching cards and mechanic punches are used as a backup system.