LINES OF COMMUNICATION

Elsbeth Heinzelmann *reports on how researchers in Berne are attempting to cripple the use of mobile phones in prisons*

Penal institutions are designed for maximum security, but illicit mobile phones undermines the system

Picture credit: Matthias Witschi

These days, if a prison does not radically stamp out mobile phones, it incurs excessive levels of risk, as drug barons and mafia bosses organise their criminal activities conveniently from the comfort of their prison cells. But if the security staff have to constantly and meticulously search the cells to find mobile phones, this means a high financial outlay. Innovative solutions are needed, like the one being tested at the University of Applied Sciences in Berne.

Prisons around the world are affected by the problem of mobile phone smuggling: they are thrown over the walls at night, hidden in the wings of pigeons, smuggled in by lawyers or secretly handed over by wives and children while visiting their incarcerated parent. In Switzerland, a man who came before the District Court of Weinfelden in 2015 made more than 160 telephone calls from Frauenfeld cantonal prison. In one call with his former girlfriend, he even tried to arrange the murder of his father.

Of course, there are various systems for localising mobile phones in buildings, but they are expensive, unwieldy and need a lot of sensors – namely one per cell. There are frequent upgrades to new telecommunication standards, meaning that all sensors and processing units have to be replaced. That's no joke when the prison has 1,000 cells.

Moreover, installation and maintenance costs have to be considered. Systems such as mobile phone blockers cost a small fortune. Such a project was planned at the detention facilities in Waldeck, Germany, costing €500,000. In 2009, Offenburg/Baden-Wuerttemberg prison put €1 million on the table for mobile phone blockers. We do not know the expenses incurred by Lenzburg prison, which set a good example last year: in a hidden spot in each cell, a sensor was installed that immediately sounds an alarm when somebody uses a mobile phone or internet stick.

WHAT ARE THERE ALTERNATIVES?

But what are the alternatives for localising mobile phones? "Commercially available mobile detection devices are used in searches, or Managed Access Solutions where whitelists precisely define which mobile phones are permitted to set up a connection", says Matthias Witschi, research assistant at the University of Applied Sciences in Berne. "An interesting option is the suppression of mobile communications using jamming systems or permanent detection systems."

Let's look at the existing systems: Managed Access Solutions need explicit base stations, an expensive solution needing clarification with the service providers and responsible authorities. Jamming transmitters are prohibited in the EU as they not only disturb the radio frequency spectrum, but can also block emergency calls to the fire, police or ambulance services. "Today's detection systems rely on many antennas, which have to be flush-mounted and wired so as to be vandal-proof. In many cases this is only possible for renovations and new buildings. But all known systems lack accuracy; they need an intelligent analysis algorithm allowing precise localisation", says electrical engineering specialist Matthias Witschi.

It is precisely this type of analysis algorithm that is at the heart of the innovation created by researchers at the University of Applied Sciences in Berne. Their goal was to create a system with fingerprinting based on the received signal strength as well as simultaneous, passive multi-device localisation. Together with their Swiss industrial partner COMLAB AG, which specialises in high-frequency technology and radio communication solutions, they started to develop a localisation system for mobile phones. It works for all three communication standards (2G, 3G and 4G) and is based on morphological filters in the frequency domain.

The fact is, if you want to localise a mobile phone you have to monitor a building section round the clock for electromagnetic signals. This requires eight permanently installed antennas out of the reach of occupants, with a reception range covering the building section concerned. A central unit processes and evaluates the signal power received from the antennas. "Because of the electromagnetic topology of the building, the received signal power differs from the power emitted by the mobile phone, depending on the position of the phone within the building", explains Matthias Witschi. "That is, each position within the building is assigned an electromagnetic fingerprint. Thanks to these fingerprints – depending on the position – we can localise the prisoner's mobile phone."

The fingerprint technology comprises two phases: In a learning process the reference fingerprints are collected from different places in the building. Then, in normal mode the localisation is performed by comparing the fingerprint collected continuously with the reference fingerprints. "As soon as a prisoner uses their mobile phone in their cell, this fingerprint technology enables us to determine the position of the device", explains the scientist.

With regard to modern communication signals, each one has its characteristic spectral shapes, which the researchers in the project use with a signal-specific optimisation algorithm. In the first step, they performed statistically robust estimations of the Power Spectral Density (PSD) of the signal received at all antennas. In the second step, the project partners carried out a signal separation with a morphological filter. The proposed algorithm is based on the assumption that the spectral shape

> **THE SYSTEM GUARANTEES CONTINUAL MONITORING WITH A MINIMUM NUMBER OF ANTENNAS**

of the interesting communication signal and the interfering signals can be clearly differentiated using morphological filters. These filters are non-linear operators, which assign an output value to a group of input values. In order to obtain the maximum noise reduction, the structural element has to be chosen so that it suits the characteristic spectral shape of the useful signal. "The detection performance shows an extraordinary robustness of the proposed algorithm with regard to the rejection of strong narrow-band disturbances", says Matthias Witschi. "We were able to observe all the signals considered with high sensitivity and a low false alarm rate."

TESTING THE ALGORITHM

In order to validate the localisation algorithm for the GSM (Global System for Mobile Communications) and LTE (Long Term Evolution) mobile communication standards, the research team cooperated with the prison in Lenzburg, Switzerland, where around 200 staff members guard approximately 300 prisoners. They had more than 20 cells on two floors and – with eight antennas in a building volume of 1,600m^3 – could localise the test mobile phone with a success rate of 90 percent. It was possible to perform these tests thanks to the temporary closure of some building parts due to renovation. The researchers were thus able to fully test the algorithm. In the meantime, the scientists have also adapted the localisation algorithm for the UMTS (Universal Mobile Telecommunications System) communication standard. As the renovations had been completed in Lenzburg, the team validated this algorithm at the former Burgdorf Castle remand prison.

"The next phase will be to install a pilot plant," explains Pascal Schwab, CTO and development manager at COMOLAB. "We are, therefore, in contact with the Swiss Bellechasse prison, which was founded in 1898 as a penal colony. For the

time being, we have to collect as much feedback as possible from our clients to continue our development." What about integration into an existing installation? Pascal Schwab does not see any problem: "We did this in a prison in Berlin, where we integrated the detection of UMTS signals into one of our current jamming systems". The system has been operating successfully since 2014. "Looking back, we can say that our system guarantees complete supervision and continuous monitoring with a minimum number of antennas. These have to be installed on the exterior wall of the building and ensure the localisation of active mobile phones to the specific cell."

JAMMING TRANSMITTERS ARE PROHIBITED IN THE EU AS THEY CAN BLOCK EMERGENCY CALLS

BETA TESTING VALIDATION

But before the system can be launched onto the market, it has to be validated in beta tests. "As soon as this phase has been successfully concluded, we can demonstrate a reference project with the above-mentioned Bellechasse prison and I see good opportunities to install the system in other European prisons", declares Pascal Schwab. "Effectively, we plan to cooperate with the prison in Berlin's Moabit district, one of the oldest remand prisons in Germany." The Swiss company COMLAB is very active in Germany, where it equips the 3,800 carriages in Deutsche Bahn's ICE 4 fleet – the latest generation of Intercity Express high-speed trains – with its high-quality repeater systems, offering train passengers 2G, 3G and 4G signals from German mobile operators ●

Elsbeth Heinzelmann studied psychology and journalism in Germany before founding a company for communication consulting in Switzerland. She now presents scientific and technical issues in national and international articles.

A prototype of the demonstration system developed by the University of Applied Sciences in Berne with active detection and localisation of smuggled mobile phones

Picture credit: Matthias Witschi