Communication in times of crisis

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Simple and robust signalling technology proves reliable in a crisis. Credit: Katrin Binner

Researchers at the TU Darmstadt around Professor Matthias Hollick are experimenting with technologies designed to empower the civilian population in times of crisis. They aim at establishing basic communications and means to share information, thus facilitating human cooperation and mutual aid even following wide-spread power and Internet outages.

Unknown hackers launched a malware attack on the Ukrainian national power grid in late 2016. The malicious software interfered with the control system and caused an hour-long power outage in parts of Kiev. In the last year, other hackers set their sights on the Domain Name Service (DNS) owned by Dyn, a US American service provider, knocking out several websites, including Netflix and Amazon for multiple hours. These are just two of the many examples that expose the vulnerability of today's high-tech society; and the German federal government regards attacks on our critical infrastructure as a latent danger.

Natural disasters or major emergencies can also isolate a region from the power grid and Internet, which is why the German Federal Office for Civil Protection and Disaster Assistance advises citizens to stockpile food supplies for crisis situations. However, the population at large dismisses this risk. What would happen if the power supply system and Internet really were to fail? Most people no longer have battery operated radios, and would be completely cut off from all information sources.

"Despite our increasing dependence on infrastructure-based networks",warns Matthias Hollick, Professor on Security in Mobile Networks at the TU Darmstadt, "no backup plans exist. Civil protection and disaster assistance has even seen budget cuts in recent years. The authorities and armed forces are able to operate their communication networks for a considerable time, even in the absence of external power supply. In contrast, the civilian population would be mostly disconnected from any means of communications."

Interdisciplinary Research Centre "NICER"

That's why Hollick and his colleagues founded "Networked Infrastructureless Cooperation for Emergency Response" (NICER), an interdisciplinary research centre at the TU Darmstadt. Its core team consists of eleven professors, three post-doctoral researchers, sixteen research associates and six associate staff members. NICER is a joint project involving the Universities of Kassel and Marburg and receives some 4.5 million Euro in funding from the federal state of Hesse within the LOEWE programme.

The basic idea is to network the population by means of infrastructureless information and communication technologies. To achieve this objective, NICER is focused on three key themes: the establishment of autonomous communication islands, the construction of bridges between the islands, and the operation of an overall network with special applications for use in crisis situations.

That's why the researchers want to establish communication islands. An island may be an urban district or a village. All mobile devices within the island would be able to communicate with one another without the need for any underlying infrastructure. Moreover, in case of large-scale disasters, there may be several such islands all existing independently of one another. Additional bridges would then need to be established to enable communications between islands. For example, a mobile device carried by a resident of one island who happens to travel to another island could function as a bridge between the two areas. It would store information destined for recipients in the other island and physically carry it there, thus enabling the exchange of information over longer distances.

One difficulty in setting up the islands is the fact that cellular base stations, which function as central coordination nodes, would no longer work. Mobile devices can only communicate directly over short distances and therefore depend on other devices that act as forwarding and distribution nodes. Data traffic management is particularly challenging following this loss in coordination capabilities. Still, to enable the prioritisation of specific data types, devices need to be able to exchange status information. Hollick's group has developed a robust, ultra-low-lateny forwarding mechanism for such status information exchanges, in which the signal emitted from a given device is picked up and broadcast simultaneously by all devices in the immediate vicinity. The message propagation can be compared with the ring waves formed when throwing a stone into a pond. The collaboration of the involved devices needs to be precise enough for the emitted signals to overlap constructively – a level of precision that the researchers also want to achieve on standard commercial devices.

To ensure that the collaboration also functions in an energy-efficient manner, the NICER researchers have been re-engineering various mobile devices in their "Emergency Response Lab" to increase their performance. For instance, each device is equipped with a so-called firmware, which is the software empowering the processors of the radio module. Under standard operating conditions, the firmware forwards incoming data packets either to the operating system or application software. After processing, they are dispatched to the intended recipient again via the firmware and radio module.

"However", Hollick explains, "if we succeed in managing the communications on the radio module processors, we could cut out several steps. Simple data packets could be processed in fractions of milliseconds, whereas using the operating system would take orders of magnitude longer. That's a significant gain if we are operating hundreds of devices." Confining the processing to the radio module also saves power, as it is no longer necessary to power up the main processor. This would extend the battery life of the devices in question – important when the power grid is down. In order to be able to utilise the firmware in this way, mobile devices would simply require a standardised emergency operating mode, which would kick in during crisis situations.

The scientists are also looking into ways of utilising the various data available within a given island to produce a shared situation report: what sensors are available? Which of them would need to be queried to produce an accurate overview of the situation without overloading the network? Signal processing experts and robotics researchers are jointly investigating how to process this sensor data. To this end they build on the communication mechanisms for interaction with the rescue robots, which could be deployed in particular challenging environments such as for instance nuclear facilities following an accident.

Last, but not least, the services that should be available within each island are also a subject of research – Apps that, for example, provide citizens with situational updates or information about relief resources. The researchers are developing ways of operating the Apps distributed across the emergency network, thus making them resilient to infrastructure outages but also to the failure of individual devices. Hollick concludes: "We're hoping that solutions based on the NICER research will soon be available to everybody. This facilitates that the affected population has the means to help themselves under catastrophic circumstances literally in its hands – namely by making use of the mobile devices they own already."

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