1. FINAL PUBLISHABLE SUMMARY

Opportunistic networking is a novel paradigm based on data storing, carrying, and forwarding by mobile nodes which exploit wireless ad-hoc communication opportunities when coming in range of one another. These networks are disruption tolerant and make use of node mobility to transfer data as visualized in Figure 1. In areas without connectivity or at the edge of the Internet, opportunistic networks are potential networking alternatives to traditional, infrastructure-based networks. Thus, opportunistic networks are applicable in situations such as search and rescue missions when infrastructure networks have been destroyed or in remote areas without sufficient connectivity, when infrastructures are overloaded and can benefit from offloading, and in disconnected regions in developing countries that should be connected.

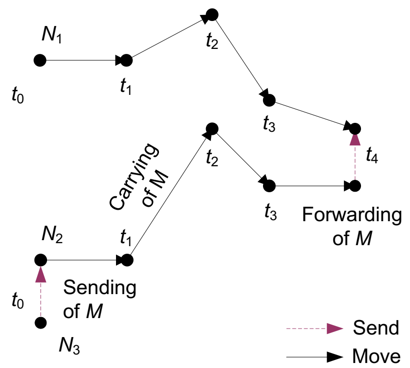

Figure 1: Opportunistic transmission of a message M.

As opportunistic networks depend on human mobility and device cooperation, they rely on a good understanding of human mobility behavior, device characteristics, and finally on the application scenario determining the data traffic and quality of service requirements. The Marie Curie EU FP7 project **MOVE-R, Improving the Realism of Mobility and Cooperation Models in Opportunistic Networks**, conducted at the Communication Systems Group, ETH Zurich, focused on three lines of investigations: (i) characterizing human mobility based on real-world mobility traces, (ii) deriving realistic device models by characterizing major properties such as energy consumption, and (iii) application-driven traffic characterization.

The **characterization of mobility** was approached by analyzing a set of anonymized, labeled GPS traces of daily human activities such as going to work or shopping, and by deriving physical mobility characteristics from anonymized 2G/3G cellular mobility data. The more accurate GPS traces showed that different mobile activities indeed show different mobility characteristics in terms of velocity, range, location revisiting behavior, etc., which can be exploited in opportunistic dissemination algorithms. The coarser granular cellular data provided insights in the mobility of a larger number of users on larger areas. It was possible to derive mobility flows on streets in a European country, Austria, and, finally, to detect traffic congestions very accurately. Similarly, user flows between cities and urban and sub-urban regions in an African developing country, Ivory Coast, have been derived from cellular data which resulted in first insights in the capacity of a hypothetical opportunistic network that could be used to connect so far not well connected populations. In such a setting, device storage, and, most of all, energy are major limiting factors. The **energy consumption of major opportunistic communication technologies** such as Wi-Fi Direct, Bluetooth, and WLAN-Opp, which has been developed at the Communication Systems Group, ETH Zurich, has been characterized.

Finally, an application-driven approach was followed in order to **identify traffic types** in opportunistic networks. All data transfers should be to some extent delay-tolerant, yet, the size of data and resulting needed throughput or channel capacity are dominant characteristics that have been investigated in the use cases *rescue missions* and *connecting disconnected populations*. In the case of rescue missions, data sizes range from small text or sensor information such as GPS locations to multimedia data such as pictures, sound, and video files. To support small and large-sized data, two separate channels have been introduced in an aerial testbed implementation of micro Unmanned Aerial Vehicles (UAVs), one to transfer UAV telemetry and GPS data implemented by the long-range technology XBeePro, and another one for large-sized images implemented by high-throughput multi-hop Wi-Fi 802.11n.

The results of MOVE-R are documented in **17 publications** and have been further disseminated during six scientific talks and three additional dissemination activities (poster, demo, and exhibition). The outcomes of MOVE-R are facilitated and extended in SWARMIX, an ongoing project at the Communication Systems Group, ETH Zurich, targeting aerial network provisioning in search and rescue missions to shorten the mission completion time, and ongoing research on connecting disconnected populations – a topic with high societal impact. Finally, we believe that in particular our results for road congestion detection based on cellular data can be leveraged by city planning and road management.

Further information about MOVE-R can be found at: **http://people.ee.ethz.ch/˜khummel/mover.html**.