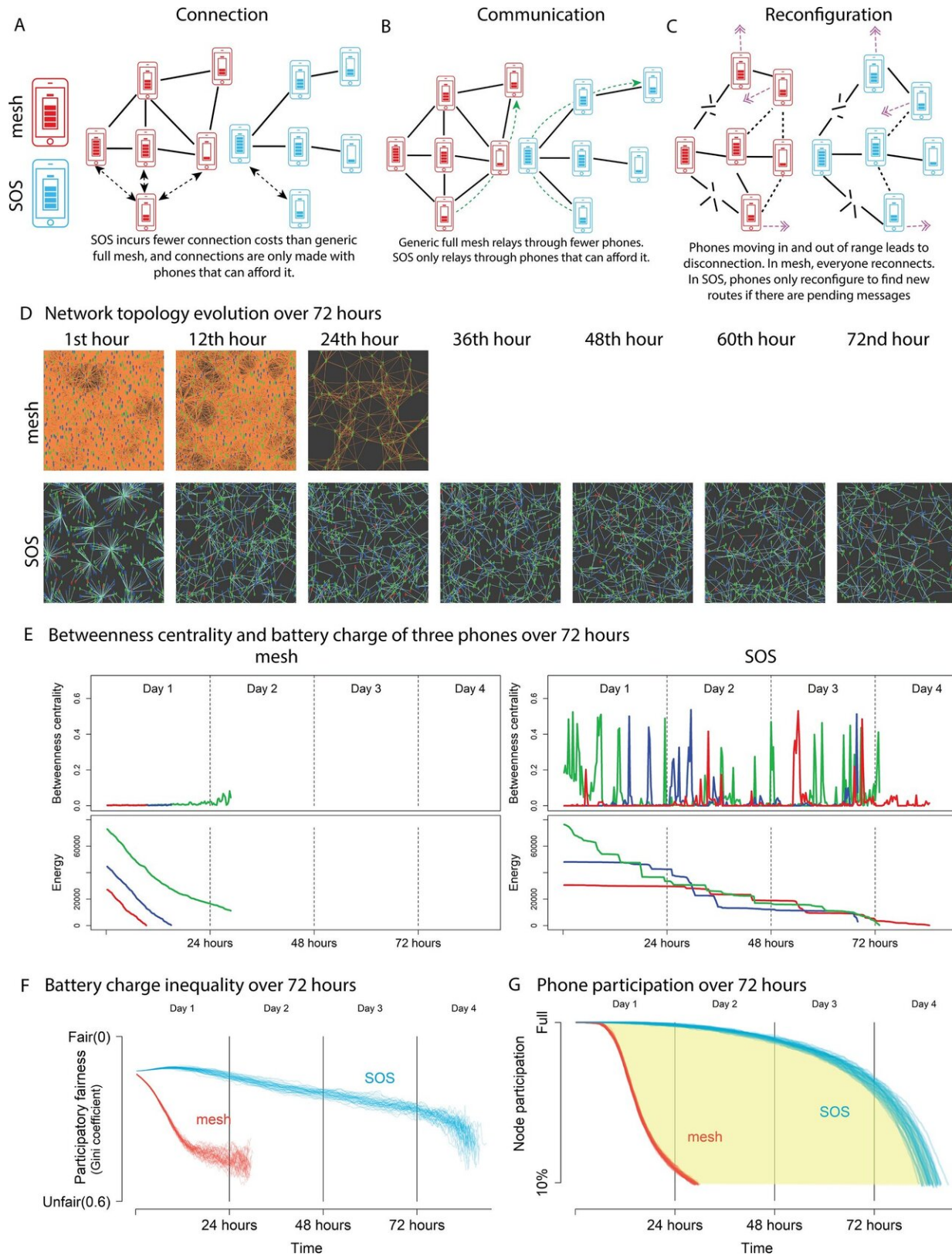# Novel disaster communication system empowers communities and can save lives

March 30 2021, by Tanja Emonts

A **Connection**

B **Communication**

C **Reconfiguration**

mesh

SOS

SOS incurs fewer connection costs than generic full mesh, and connections are only made with phones that can afford it.

Generic full mesh relays through fewer phones. SOS only relays through phones that can afford it.

Phones moving in and out of range leads to disconnection. In mesh, everyone reconnects. In SOS, phones only reconfigure to find new routes if there are pending messages

D **Network topology evolution over 72 hours**

| 1st hour | 12th hour | 24th hour | 36th hour | 48th hour | 60th hour | 72nd hour |

mesh

SOS

E **Betweenness centrality and battery charge of three phones over 72 hours**

mesh

SOS

F **Battery charge inequality over 72 hours**

G **Phone participation over 72 hours**

(A) Differences in connection, (B) communication and (C) reconfiguration

patterns between a generic mesh protocol (red) and SOS (blue). (D)–(G) Results of simulations with 500 phones, sending and receiving 1 message per phone every 15 min for the generic mesh and SOS protocols. (D) Formation and evolution of the mesh (top) and SOS topology (bottom). The ad hoc mesh network runs just longer than a day. SOS runs for the entire duration of 72 h. (E) Development of Battery charge (Energy) and Betweenness Centrality for a selection of three typical phones (red: low initial battery charge; blue: average initial battery charge; green: high initial battery charge) Left: mesh network; right: SOS. In the mesh network, every phone has the same Betweenness Centrality. In SOS, the Betweenness Centrality fluctuates, with green starting as a central hub; a role which is later taken over by blue and then red, as the relative battery charge changes. This ensures that all phones can equally participate in communication for an extended time period. (F) Development of battery charge inequality (Gini coefficient52) over 72 h for the mesh network (red) and for SOS (blue). (G) Phone participation over 72 h for the mesh network (red) and for SOS (blue). Credit: *Scientific Reports* (2021). DOI: 10.1038/s41598-021-86635-y

Even a low phone battery can mean the difference between life and death during disasters. With the help of TU Delft researcher Indushree Banerjee, the opportunity to communicate and be rescued is no longer dependent on owning an expensive phone with a long-life battery. She has designed a novel energy-efficient and reliable emergency communication system using smartphones, that maximizes the number of people who are able to communicate during a longer period of time. Banerjee's research is published in *Scientific Reports* on 30 March.

Digital divide and a value-based system

The first 72 hours after a disaster are especially crucial for survival, when (inter)national rescue parties are not yet on the scene. Reliable communication is of essence for self-organized rescue. During disasters,

however, blackouts most often prevent citizens from charging their phones; only those with battery charge at the point in time can communicate. This is an unwanted situation and instigated Banerjee to develop a value-based emergency communication system based on participatory fairness: the Self-Organisation for Survival (SOS) emergency communication system.

How it works

Banerjee: "A phone loses battery charge when connecting to another phone or when sending, receiving, or relaying a message. SOS is designed in such a way that phones choose to connect only with one other phone, the one with the highest battery charge in their transmission range. As people move around, their phones switch connection when appropriate. By limiting the number of contacts and switching connections, the phone battery will last a lot longer and prevent any single phone from being unnecessarily overused."

This is in contrast with the generic mesh topology that underlies current emergency communication solutions. These solutions form so many connections that they do not last the crucial 72-hours. In the SOS system, the phones with lower battery charge are being spared, such that participatory fairness and a longer network lifetime is achieved.

"SOS enables collective sharing of energy resources when most needed, providing the basis for a truly socio-technical participatory system," say Frances Brazier, professor of Engineering Systems Foundations and Martijn Warnier, professor of Complex Systems Design, both at TU Delft who supervised Banerjee together with Dirk Helbing. Helbing, Professor of Computational Social Science at ETH Zurich and affiliate professor at TU Delft, says: "The SOS system truly is a big step forward in achieving participatory resilience of disaster-struck communities."

Robust and reliable

What makes the system robust and reliable is its capacity to automatically reorganize when connections fail, when people move around or when a phone leaves the network. Without any user involvement the SOS communication network automatically and dynamically assigns high-battery phones as hubs and adapts the topology to changing population density and [battery](#) charges. Comparative agent-based modeling demonstrates that, compared to a conventional mesh communication network, the SOS network design results in fair participation of all phones and a longer network lifetime. This helps make communities resilient, limiting the impact of a disaster and to save human lives.

Next step

So far this concept has been tested in computer models. The next step is to develop the actual app so that the SOS emergency [communication](#) system can be tested in real life. Banerjee together with other researchers is now seeking cooperation with international humanitarian aid agencies to get this started.