# 36. Measuring crowd densities for safety and efficiency

Events like concerts, festivals and sporting competitions often attract a crowd of people. The same can be the case for institutions like museums, hospitals and amusement parks. We have developed a real-time visualization of how the density of a crowd changes.

In our demo we will ask volunteers from the audience to wear our electronic badge. This badge will monitor the surrounding density of its user in real time. The measured densities will be made visible on one or more screens. By giving instructions to the volunteers, we will also be able to show real-time changes in density measurements. All these measurements are done in the network, so that there is no offline, central server needed.
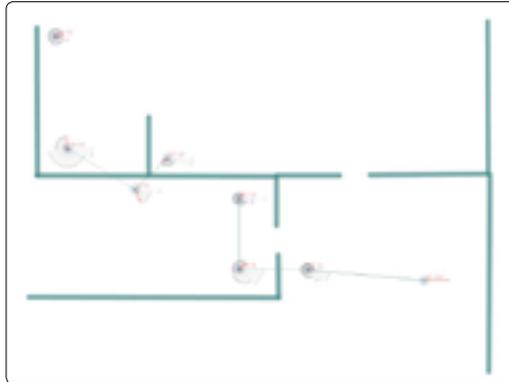
ICT science question
The scientific challenge is how to reliably estimate the number of people that are in the neighbourhood of each person. Each person is a node in a constantly changing network. This estimation is a scientifically hard problem, because we consider mobile networks with high densities: each node has typically hundreds of neighbours. An additional challenge is that all nodes estimate the number of neighbours at the same time.

Application
Tracking the density of crowds in real time can contribute to a safer and more efficient way to deal with crowds. Our estimator (called Estreme) can at the same time estimate the neighbourhoods of one hundred nodes with an error below ten percent. Competing solutions presently provide a similar accuracy, but only on networks consisting of a few tens of nodes, where only a fraction of them estimates the number of neighbours at the same time.

Alternative Application
Due to its simplicity, our algorithm can also be used in wristband devices. This makes it more practical and attractive for potential customers than using the badges, as in our demo.

Nice to know
We have implemented our crowd density measurement tool in an open source operating system for the Internet of Things. We will soon use it at the Cobra museum in Amsterdam to monitor the flow of visitors and identify hot spots.

Events like concerts, festivals and sporting events often attract large crowds. Estreme provides a simple solution for real-time visualization of crowds, which is important for planning and safety.

Estreme is a low cost wristband that can be given to all attendees in an event. This wristband preserves the privacy of people but allows a real time monitoring of the crowd.

Estreme tracks crowds in real time, which makes an event safer and more pleasant. It can cope with higher densities than existing solutions (100's of neighbors) with the same low error (below 10%).

Estimating the density of crowds is a hard problem because it requires monitoring mobile networks with high densities. Estreme uses periodic but asynchronous radio signals to solve this problem.

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COMMIT/ project
EWIDS Very large wireless sensor networks for well-being

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