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► **To cite this version:**

Julien Beaudaux, Antoine Gallais, Romain Kuntz, Julien Montavont, Thomas Noel, et al.. Demo Abstract: CASINO: Creating Alea with a Sensor-based Interactive Network. ACM Conference on Embedded Networked Sensor Systems (SenSys 2010), Nov 2010, Zurich, Switzerland. pp.381-382, 10.1145/1869983.1870033 . hal-02650620

HAL Id: hal-02650620

<https://hal.science/hal-02650620>

Submitted on 29 May 2020

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Demo Abstract:

CASINO: Creating Alea with a Sensor-based Interactive Network

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Abstract

In this paper, we briefly describe an interactive roulette game enabled over a wireless sensor network platform. It basically consists in a train speeding in one way (the spinning roulette) and in a message hopping along some deployed sensors in the other way (the wheeling ball). This demonstration aims at illustrating in an interactive manner the high radio channel randomness in dense wireless sensor networks, as well as its impact on the communication protocols.

1 Introduction & Motivations

Experimentations in Wireless Sensor Networks (WSN) have attracted much attention for a few years. Indeed, to model and simulate such environment is an harassing task, requiring an exhaustive (and impossible) characterization. Thus, testbeds are currently the unique solution to validate the performances of a system and eventually to exhibit new challenges that may arise only in real-life conditions.

A WSN is by nature random: radio propagation is rarely entirely predictive and owns a part of randomness [3], most MAC layers use a CSMA-CA approach (e.g. [5]), based on pseudo-random decisions in order to limit the channel contention, routing decisions can be probabilistic to balance the load in the network [2], localization techniques may take benefit from probabilistic estimations [4], etc.

We propose in this demonstration to exhibit visually this randomness, and to demonstrate that a testbed with the same inputs can lead to different resulting actions. We propose an analogy with the casinos, and more specifically with the roulette. Users provide inputs to the experiment, and a pseudo-random result will be provided when it terminates.

The demonstration integrates a roulette table: the testbed itself, constituted by all the static sensor nodes. To each sensor is assigned a number. The train represents the mobile part of the roulette table, capturing the ball when the experiment terminates. Finally, the ball is virtually represented by a message, acting as a token, jumping from one sensor (number) to another.

The testbed takes into account several sources of randomness. Obviously, the radio propagation is not controlled: the multipath, shadowing, etc. will greatly affect the signal propagation. In the same way, we implemented a CSMA-CA



Figure 1. Our 3D WSN grid composed of 256 nodes and a mobile train.

opportunistic MAC layer, introducing some randomness. Finally, the ball acts as a token and is forwarded probabilistically: we implemented a geographic routing protocol, relaying the *ball* to the most accurate next hop. When the solution terminates (the ball reached its destination), we implement a geolocation solution with multilateration, associating the stopped ball with one number (the closest sensor).

All these protocols constitute an independent challenge, and this demonstration aims at highlighting their interactions. We are convinced we have to take benefit from randomness instead of smoothing the performances, argument already developed in several propositions.

2 Platform architecture

We deployed in the university of Strasbourg a testbed with 256 nodes deployed in a 3D grid topology (fig. 1). We introduced a controlled mobility by inserting a moving train, embedding several sensors. We can have a remote access to this platform as well as a realtime feedback with a mobile webcam. This testbed is part of the SensLAB project [1], a national platform for Wireless Sensor Networks (funded by the ANR through the SensLAB TLCOM grant).

Results of the game are visualized through a 3D interface that renders estimated positions. This way, in addition to the moving train and the flooded message, the player should also face the radio channel randomness that impacted both geolocation estimation and message routing.

At Sensys, we plan to have a small part of the testbed, with static sensors placed in the showroom while some others will be given to some conference attendees. Other attendees will bet and a croupier will virtually launch the message through the actuation of a sensor. Mobile sensors will be attributed static values. This will be in addition to the remote interaction with our 256 sensors platform, from which video feeds will be retrieved.

3 Demo description

The player virtually launches the message in the grid and the train is also randomly speeded. Each static sensor has a unique identifier while mobile nodes are given a color. All sensors are battery powered. The goal is to bet both an identifier (the sensor in front of which the train will stop) and a color (the mobile node that finally kept the hopping message). The overall process is depicted in Figure 2. We implemented an out-of-band management (with either Ethernet or Wifi for mobile nodes).

The wheeling ball The wheeling ball is symbolized by a message hopping over deployed sensors. A node is randomly chosen to generate the *ball*, fixing the TTL proportionally to the light intensity it senses. The message is then forwarded in the 3D grid and TTL is decremented before each new transmission. Once $TTL = 0$, the message is dropped.

We implemented a geographic routing: each node forwards the *ball* according to a privileged direction, following the train path. When a node has to forward a message, it constructs the sector spanning a given angle, and pointing in the direction tangential to the circle (the spinning roulette, fig. 2). So far, the angle has been set to $\frac{\pi}{2}$. Any node located in this sector is candidate for forwarding the message.

We implemented an opportunistic MAC: each potential next hop, after having received a message, triggers a timeout proportional to its distance to the direction of the sector. A node cancels the forwarding if it hears another node forwarding the message, acting as an *implicit ack*. Because we do not evolve in an idealized environment, several nodes may forward one messages, creating virtually several *balls*. On the contrary, a transmission error may *destroy* the ball. While multiple hopping messages do not endanger the game, the second case is more complicated as it will result in stopping the ongoing game. Yet, such a situation remained rare during our experiments, especially due to the very large number of sensors potentially involved.

The spinning roulette The spinning roulette is symbolized by a train moving along a circular path within the 3D grid (see Figure 1). Its initial speed is set proportionally to the intensity of light sensed by one of the mobile sensors. A counter, noted as *Age* and initialized at 0, is then incremented every 500ms until the train finally stops. When a mobile node receives a message transmitted by any fixed sensor, it compares the TTL with its own *Age* value. If both are equal ($Age = TTL$), it acknowledges immediately the transmission, virtually *capturing* the ball and stopping the forwarding by any static sensor. A mobile sensor that hears another

ack considers that another mobile sensor *won* and *captured* the ball.

The final result The winning color is thus of the mobile node finally retaining the *ball*. Besides, a mobile sensor tries to estimate its location by measuring the received signal strength intensity (RSSI) with some static sensors. After a triangulation, the mobile node can estimated what static sensor is the closest: the associated number is considered as *winning*. Note that randomness is issued from wireless communications during message routing, MAC and geolocation based on RSSI information.

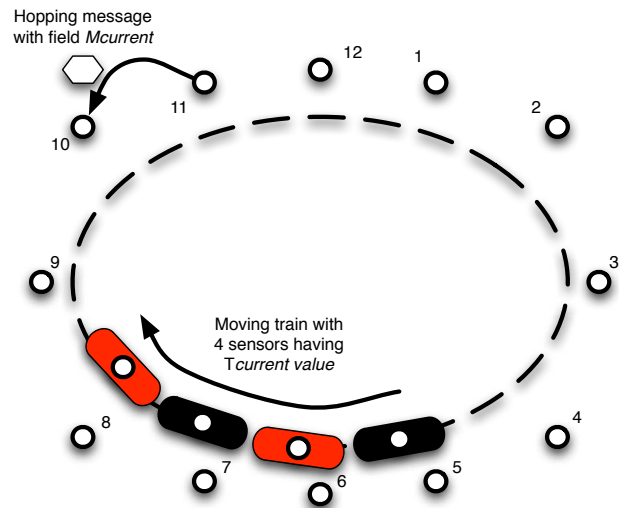


Figure 2. TTL is decremented while Age increases. A mobile node verifying $TTL = Age$ acknowledges the hopping message, defining the winning color. It then starts regular *hello* message transmissions and stops the train. Its position is evaluated based on a geolocation process. The closest static sensor indicates the winning number.

4 References

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