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IoT: lecture 6

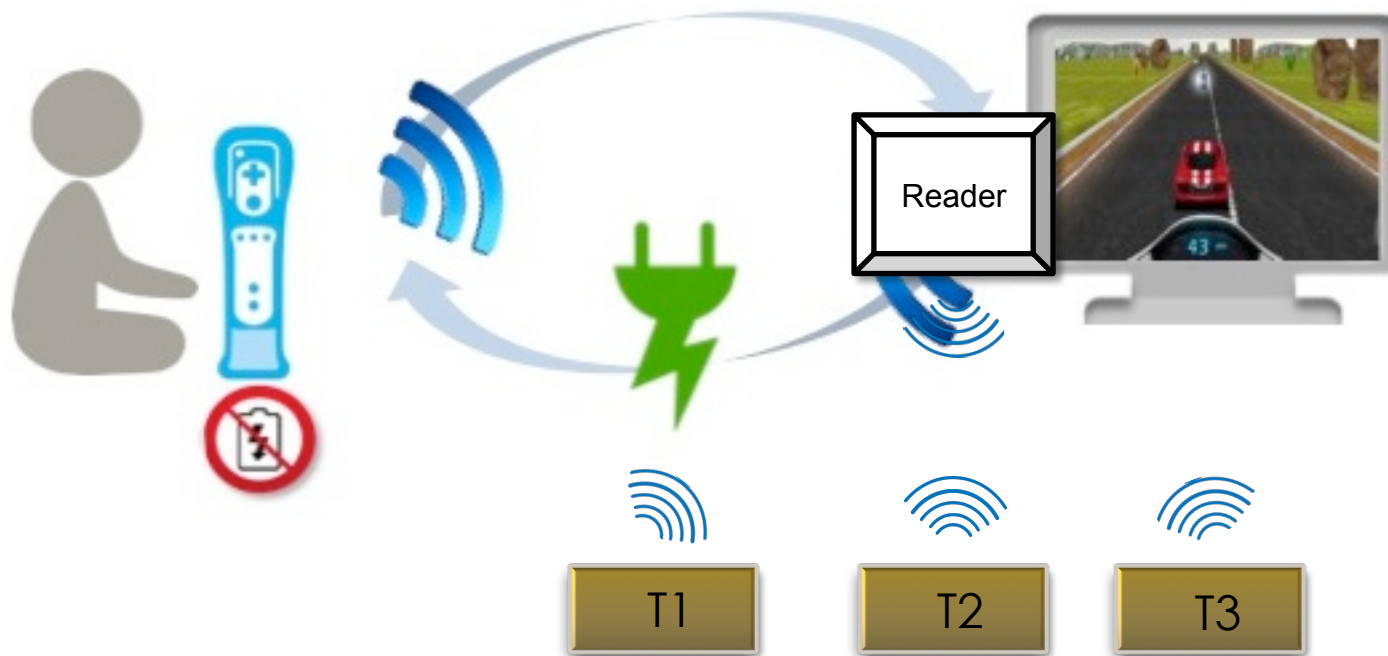
Gaia Maselli

Dept. of Computer Science

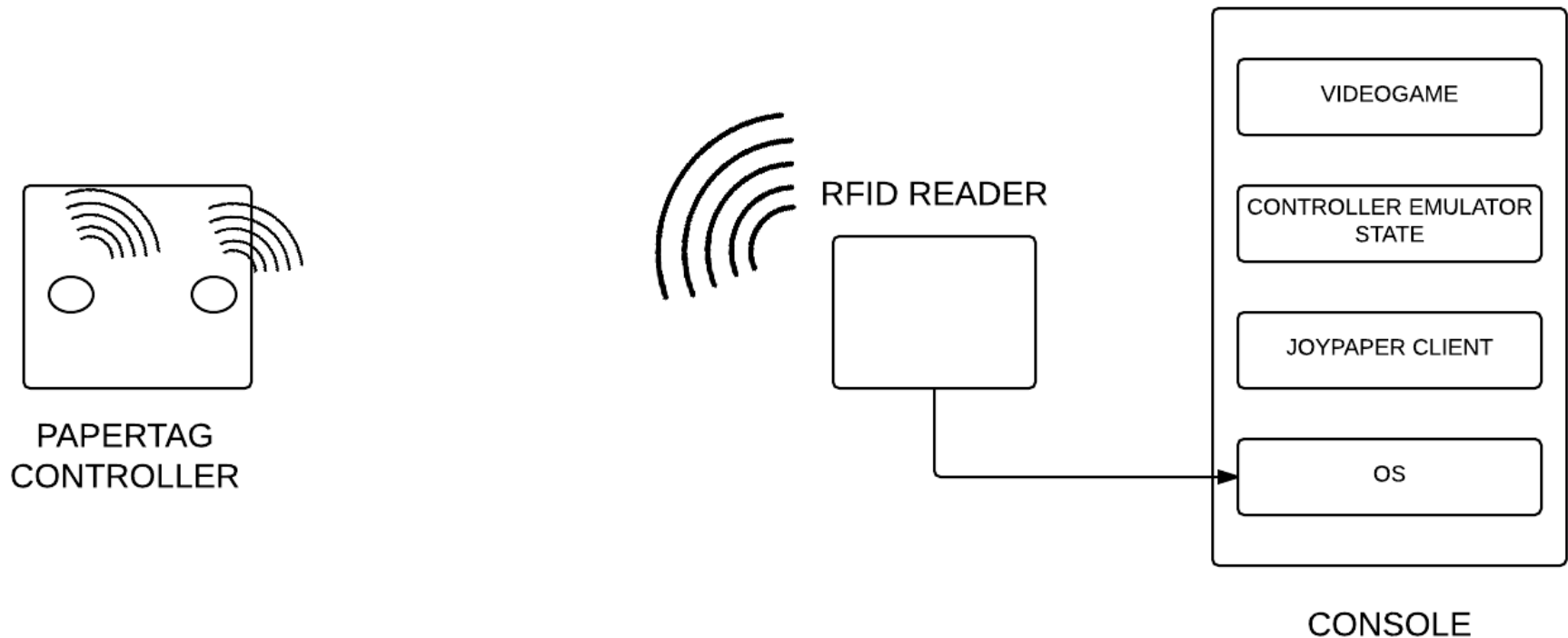
A videogame controller
based on EPC Gen 2 standard

Battery-less videogame controller

- Can we realize a battery-less videogame controller by using a commercial RFID system?



System architecture



The system is composed of two main actors: a JoyPaper and a fixed videogame console

JoyPaper

- The JoyPaper is a wireless and battery-less videogame controller that interacts with the videogame console and supports several types of single player videogames, such as adventure, action, puzzle, and RpG.
- JoyPaper features pressure buttons and is made only of paper and passive RFID tags.
- two pressure buttons
- (the other buttons are represented only to show that it is possible to include multiple buttons).



JoyPaper

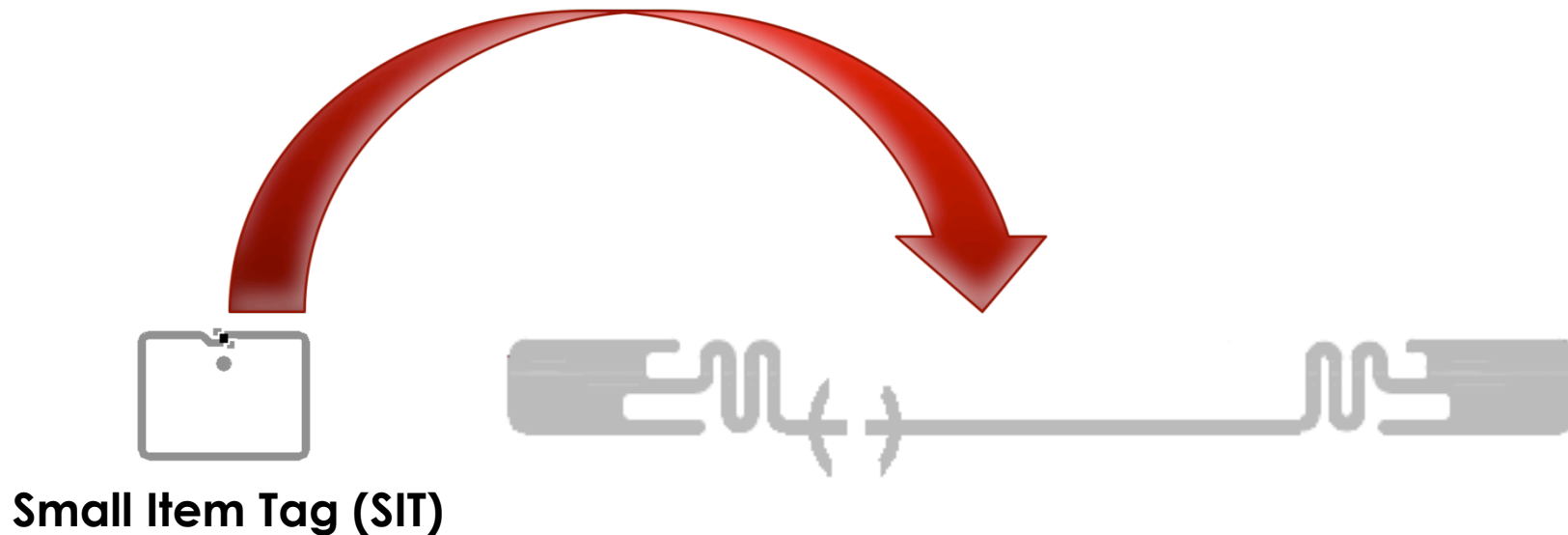


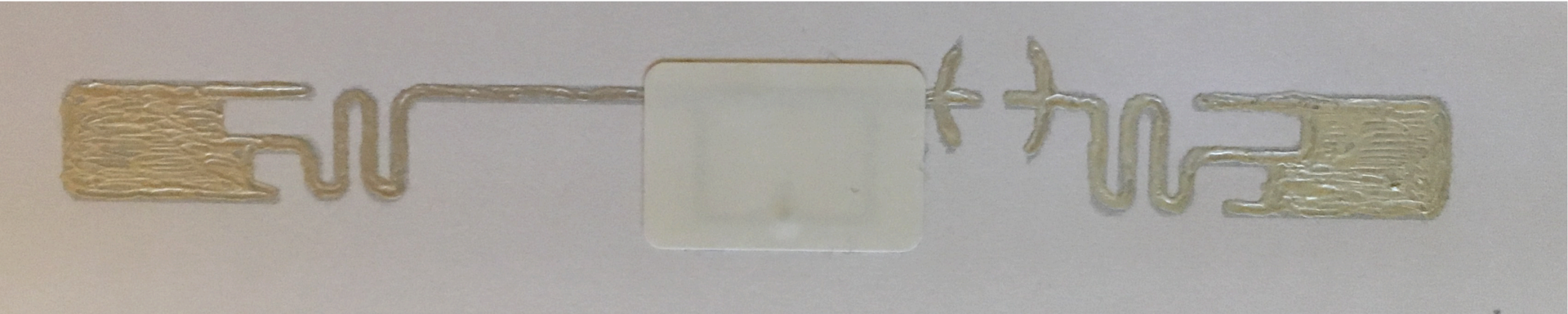
- The key idea in the JoyPaper design is to use tags with touch-sensitive antennas that act as pressure buttons.
- When the user touches the antenna of a tag (the touch activates the antenna, making the tag able to communicate with the reader, which interprets the communication as a button pressure: the tag's ID indicates which button has been pressed).
- When the user does not touch the antenna, the tag is off, unable to send/receive any data.



JoyPaper

- **Small stickers** containing commercially available UHF loop integrated circuits (IC) are placed **over specifically designed conductive traces**, that can be easily drawn by hand using a pen filled with conductive ink





- The traces capacitively couple to the existing tag antenna, providing a new antenna for the loop tag without requiring any electrical contact with the existing antenna.
- The resulting antenna detunes the tag sufficiently that it can no longer be read.
- If a particular traces spot (circle spot) is touched by a user finger, his body serves as ground plane, boosting the reflected signal: the antenna's continuity is restored and then tag starts to operate again (i.e., it receives a reasonable amount of energy to be activated).

Communication protocol

- Based on EPC gen 1 class 2 standard protocol
- At setup, the reader performs **an interactive discovery phase** to identify the tags that are on the controller and associate them to buttons (e.g., right and left buttons). To this end the reader uses the EPC **inventory** command by transmitting a query every 300 ms (this is the minimum time interval allowed by the EPC implementation).
- Tags replies by sending their Electronic Product Code Identification (EPC ID) and a cyclical redundancy check (CRC). If CRC verification is successful, the tag is correctly identified.
- At the end of the discovery phase the reader has a list of present tags and corresponding associated buttons.

Communication protocol

- In the **playing phase**, the reader continuously queries tags to check if they are active (the user is pressing the corresponding button) or not.
- The EPC **access** command allows to directly query individual tags by specifying their EPC ID. If the user is touching the button related to the accessed tag, then the tag will reply to the reader — representing a button pressure — otherwise it will not receive any query and thus will remain silent.
- As the reader is directly querying tags (accessing them based on their ID) collisions among tags cannot happen. Even if the player is pressing two buttons at the same time, tags are accessed singularly and each tag at a time will reply to the reader.
- Synchronization of pressures is guaranteed by the fact that tag accesses are very fast — a tag access takes only $60ms$ — so the reader reads a tag multiple times during a finger pressure. This redundancy add also robustness against packet errors.

Performance evaluation

Testbed



Performance evaluation: goal



- To show that JoyPaper allows to efficiently interact with a videogame
- Setting performance requirements for videogame is very difficult
- If JoyPaper performance are **comparable** with those of a **commercial controller** then JoyPaper is efficient in reporting data to the videogame and allows for a satisfying game experience

Performance evaluation: metrics

- **Reaction time**: the time between the pressure of a JoyPaper's button and the corresponding action on the videogame console.
- Reaction time is an application layer metric
- Given the nature of testbed components cannot be measured at the network layer (packet delay)
- **Throughput**: amount of bits received by the reader per unit of time
- **Packet error rate**: the fraction of incorrect packets over the total number of sent packets

Measuring reaction time

- We cannot measure packet delay at the network layer, because we use the EPC standard communication protocol and it does not allow to insert measurement code, thus we have to measure time at the application layer (i.e., reaction time).
- Reaction time then includes not only the packet delay at the network layer but also the delay incurred due to the several levels through which data passes inside the console.
- To measure reaction time we used a digital video-camera, framing the controller and the console monitor at the same time so as to have a unique clock to record button pressures and corresponding actions on the videogame console.

Results

Device	Time	95% confidence interval
JoyPaper	144,4	(134.30 , 154.49)
Logitech	104,5	-

Table 1: Results on Reaction Time.

- JoyPaper achieves over 1*kbps* of throughput, with only 0.02 of packet error rate.

Demo



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Reading material

- G. Maselli, G. Salierno, **Performance Evaluation of a Battery-Free Videogame Controller**, to appear in *ACM PE-WASUN 2017 Symposium*



Summary

- RFID identification protocols
 - Sequential (FSA, TSA, QT, BS, BSTSA) + EPC G2C1
 - Concurrent (ICQT, TIANC, Buzz)
 - A battery free videogame controller based on EPC G2C1 (JoyPaper)
- Backscatter networks with **sensor-augmented RFID tags**
 - Batteryless videogame controller based on Moo tags (JoyTag)
 - Recent topic that requires new protocols for information collection

Information collection in backscatter networks

- Problem: to design efficient protocols to collect sensor-produced information from the tags.
- Are RFID identification protocol suitable for information collection?
- What are the main differences between backscatter networks (with sensor-augmented RFID tags) and classical RFID systems?