

SmartBag: Intelligent Medication and Equipment Management for EMS Providers in the Prehospital Environment



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Abstract

EMS Care Providers are faced with a large number of tedious tasks which detract from their primary role of providing lifesaving patient care. Daily truck checks and resupply between calls occupy as much as 10% of a 12 hour shift,¹ and are absolutely critical to providing quality care, yet compliance with equipment check procedures is frequently poor. We present SmartBag, an intelligent medication and equipment management system, to automate the equipment management process and allow care providers to focus on their primary task.

Background

Accurate inventory management is critical to quality prehospital emergency medical care. A piece of equipment may stay unused in a bag or vehicle for months, but care providers still need to access it at a moment's notice, and be confident that it is still functional. Current management practices are essentially unchanged since the advent of ambulance services, the only distinction is that modern paramedics have *even more* equipment that they must manage - a modern ambulance may have more than 500 items onboard!² The current widespread practice is for crews to perform a daily truck check, and afterwards resupply items between calls as needed. However, this approach has numerous drawbacks – truck checks are tedious and are often rushed or not performed in their entirety, despite policies mandating them. Furthermore, humans are prone to error, and are not skilled at monitoring the environmental constraints that many medications are subject to.

System Goals

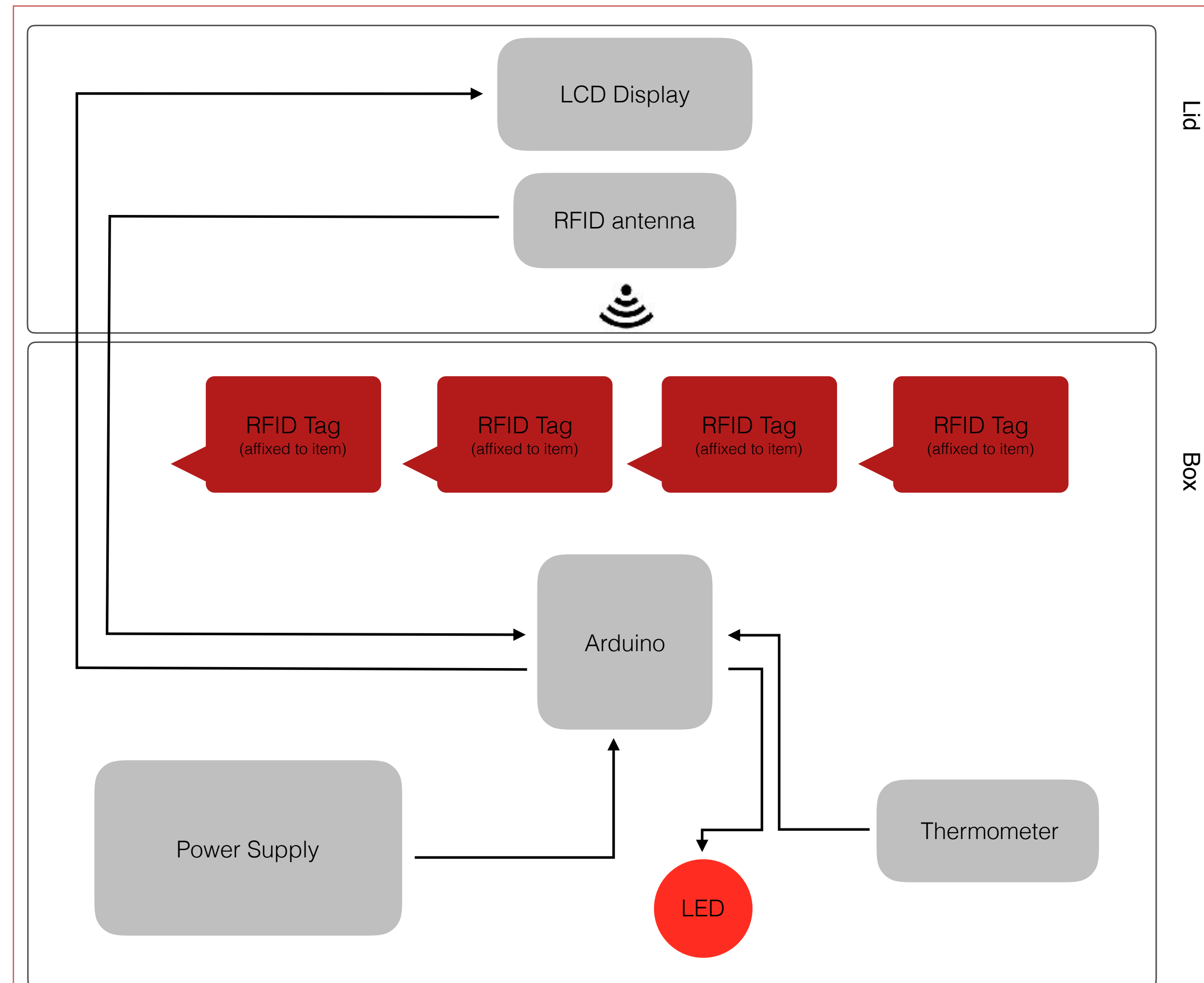
- Offload the cognitive load of equipment management from care providers.
- Provide an easy-to-use interface which will not impede access to gear in emergent situations.
- Automatically track the environmental constraints of medications and supplies, including temperature limits and expiration dates.
- Notify users of expired, damaged, or missing equipment to prevent compromised care.
- Allow exchange of items between multiple bags.

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Functionality and Methods



SmartBag consists of a central Arduino micro-controller, an external LCD display, an internal RFID antenna, and a thermometer. Items added to the bag are affixed with a small, inexpensive, and disposable RFID tag, which is encoded with the type of item, the expiration date, and the item's valid/invalid status. By encoding all the information on the item itself, and avoiding the use of a central item database, SmartBag need only monitor the expiration and environmental constraints, allowing items to be seamlessly transferred between different bags, each one of which could have a different inventory of items. In operation, the system monitors and updates items and needed, and notifies the user if items are missing, expired, or have violated their environmental constraints.

Evaluation and Results

SmartBag effectively is able to track the 4 sample medications placed within the prototype box. For the development of our prototype, we focused on medications because, of all EMS supplies, they are the most volatile. The sensing range of the RFID antenna was arguably the most difficult aspect of the project to manage, as although the antenna supports simultaneous reading of multiple cards, it doesn't perform consistently, and the read performance decreases the further the card is from the antenna. Despite these difficulties, we were able to achieve a system that achieved the primary design goals for the project, and through testing, learn the greatest weaknesses of the system to inform further refinement.

Medications & Constraints

- **Albuterol** (Ventolin) – treatment for *Asthma*
Albuterol is a bronchodilator that is administered by a nebulizer. Albuterol is sensitive to light.
- **Aspirin** (Bayer) – treatment for *Cardiac Conditions*
Aspirin prevents blood from clotting and is indicated in individuals with a suspected myocardial infarction.
- **Epinephrine** (EpiPen) – treatment for *Anaphylaxis*
Epinephrine is a vasoconstrictor and a bronchodilator and can reverse allergic anaphylaxis. It is temperature sensitive.
- **Oral Glucose** (Insta-Glucose) – treatment for *Diabetic Shock*
Oral Glucose is a fast-acting sugar that is quickly absorbed into the blood and can reverse hypoglycemia in diabetics.

Future Improvements

While we believe that our system offers a great detail of utility in its current state, a number of additional features or refinements would address some of the issues mentioned in the previous section.

- Wireless internet access, via either WiFi or a cellular data connection, would enable the transmission of alerts to the user. Alerts could be provided for numerous situations:
 - The temperature of the bag is approaching a dangerous point.
 - A medication will expire soon.
 - An item has expired or exceeded its environmental constraints.
 - An item is missing and needs to be resupplied before another call.
- A dedicated Android application for adding items to inventory would make for a substantial improvement in the user experience. This app could use the phone's camera to scan a medication, automatically note the medication type, expiration date, batch number, and write all the information to the RFID tag to be affixed to the medication.
- A more powerful RFID antenna would enable the scanning of items from a greater distance, which would allow more items to be placed in the bag.
- With the addition of a lid sensor and a buzzer, the bag could audibly alert the user if the medication was no longer potent.

References

- ¹Thom Dick, "Start your Ambulance Checks with the Essentials," *Journal of Emergency Medical Services*, 21 June 2013.
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