# TOSNOS: To Online Shop, or Not-to Online Shop – Enabling Combined Improvements

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***Abstract*—In the recent years, there has been significant research, along with the development of related system, targeting both online shopping settings, as well as location-aware marketing/advertising and surveys. In this paper, we present TOSNOS – a prototype end-to-end system that enables efficient and effective shopping experiences for individuals as well as households. Specifically, we provide a solution that seamlessly integrates: (1) automatic generation of items to be included in a shopping list using IoT sensors, (2) the generation of orders to an apriori prescribed online vendor for each item on the shopping list, (3) the detection of user's proximity to an actual store location, and (4) the generation of a notification regarding items that are on sale in the nearby store, which also happen to be in the user's online order and for which the nearby store may be offering discount prices.**

**Our solution not only incorporates different shopping possibilities for the users, but it also enables integration of location-awareness with the user's budget vs. time management. The demo will provide a step-by-step illustration of the main interacting modules of the system, including IoT sensors, database unit, and user interfaces. Furthermore, it will illustrate different heterogeneous functions of the TOSNOS system using example use case scenarios.**

***Index Terms*—Wireless Sensing, Internet of Things, Online Shopping, Database Management, Location Aware Marketing, Mobile Networking, Pervasive Computing**

## I. Introduction & Motivation

According to the U.S. Census Bureau, throughout 2019 the number of online grocery shoppers has reached 93 million – an increase of 35 million with respect to 2018 [1]. Many major vendors (e.g., Target, Home Depot, Walmart) along with online search and shop-enabling companies (e.g., Amazon) have provided applications that make it easier for the end-users to select the items to be purchased and place an order, while offering various discounts not only in terms of items pricing but also in terms of the cost of delivery [2]. Given the significant portion of the market-share, various studies have been undertaken for the purpose of investigating the impact of the technological components and advanced on the shopping behavior of customers [2], [3].

Although the current societal trends indicate that the growth-rate of the E-commerce is three times the growth of the retail [4], still, a sizable portion of the population is conducting in-store shopping. Figure 1 illustrates the grocery shopping trends – where the freshness of the product and quick availability for consumption likely plays a significant role. However, the patterns of shopping behavior and preferences vary with respect to the categories of items. But few examples follow, illustrating the percentage of customers that prefer purchasing online vs. in-store, for a few common categories of items (cf. [5]). We note that, for each item, the missing percentage values are customers who have reported equal preference between in-store and online.

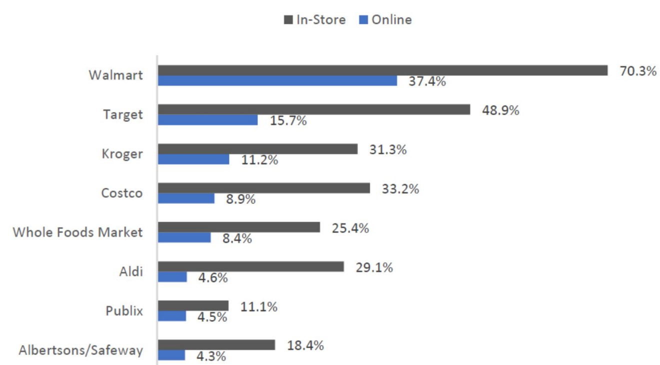


Figure 1. In-Store vs. Online Grocery Shopping (from [1])

– 32% of the clothing items are purchased online vs. 29% in-store.
– 66% of books and media are purchased online vs. only 17% in-store.
However:
– 59% of auto-parts purchases are preferred to be done in-store, vs. 25% online
– 42% of the beauty products are purchased in-store vs. 31% online.

From a complementary perspective, a popular marketing-trend towards increasing in-store purchases is the location-aware advertising [6]. Multiple solutions and systems have been proposed [7] that, based on the user's whereabouts and the proximity of particular stores, provide various discount-coupons (with limited time-validity) for items of potential interest.

There are multiple contexts that permeate the decision whether shopping should be done online or in-store. Motivated

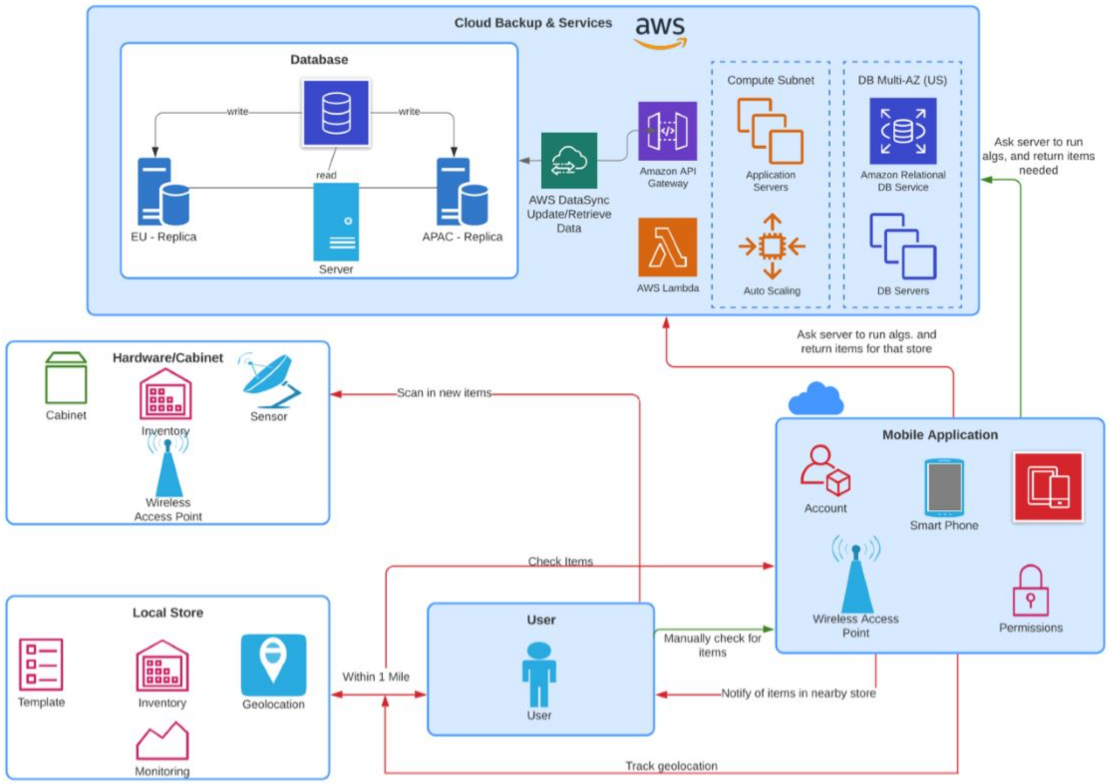


Figure 2. Basic Components of TOSNOS

by this, instead of focusing on improving such shopping experiences in isolation, we addressed the goal of enabling a collaborative coupling of such activities. The proposed TOSNOS (To Onlilne Shop or Not-to Online Shop) system provides an end-to-end IoT (Internet of Things) based solution that involves:

- Automatic detection of grocery items that need to be purchased, by both sensing of the weight and scanning of the products in refrigerator/cupboard shelves, if the quantity or amount of any specific item falls below a predetermined threshold for that item.
- Automatic update of the data for generating a corresponding online purchase order.
- Location-aware notification for the users that certain items on the shopping list are available in a near-by store at acceptable prices.
- Automatic updates of the online orders, upon users selection to perform in-store purchases.

In the rest of this paper, we discuss the overall system architecture and its different modules, and present the details of the demo-steps.

## II. TOSNOS Architecture

Figure 2 illustrates the main modules of the TOSNOS system, and also depicts the typical interactions of a given user.

**(I) – Data and Events Generation**: The left portion shows the main sources of events that could potentially trigger an action:
I.1 – The in-home IoT system that detects the status of the inventory in the refrigerator or pantry/cabinet shelves, for a given pre-selected set of items. We note that, upon the first start/initialization of the TOSNOS, the user is expected to generate the list of to-be-monitored items of interest via mobile app. We note that the mobile app allows the user to select a particular time of day (e.g., midnight) at which an online order will be placed for the list of items the reserves of which have dropped below certain threshold.
I.2 – The proximity of a store which carries items that match (a subset of) the list of items for which an online order is pending, along with their prices. The user has the option to set a parameter of preferred/acceptable distance to a given store (e.g., 1 mile in Figure 2).
**(II) – Mobile App**: The lower-right portion of Figure 2 illustrates the second individual-user component. The mobile app enables the user to perform two complementary classes of activities:
II.1 – Execute one final approval (or disapproval) of the purchases set to be ordered online.
II.2 – Upon deciding to visit a store, verify the list of items that were purchased in the particular store, for the purpose of adequately updating the pending online orders.

We note that the app also enables an “over-ride” mode. In this mode, the user can manually initiate the search for near-by stores, and use the corresponding apps of the vendors to select a list of items to be purchased from a given store, regardless of the inventory and what is contained in the pending order status. In such case(s), upon completion of the purchase, the corresponding data items from the pending orders are again checked with respect to the manually-executed purchases.

The main research challenge was to develop and synchronize the algorithmic solutions for managing the reactive behavior across multiple data sources (events generation), some of which may have "proactive" impact in terms of changing the outcomes of existing orders.

**(III) – Server and Database**: This is the core component of TOSNOS when it comes to enabling the scalability of our solution. The module has a two-fold purpose:

III.1 – It manages (i.e., records and updates) the data pertaining to the different items detected to be in deficient quantity; the orders; and shopping list for the registered users. In addition, it maintains the list of items currently available in a given store.

III.2 – It manages the location data of the registered users, along with the maps that contain stores' location data.

## III. Interaction and Demo-Steps

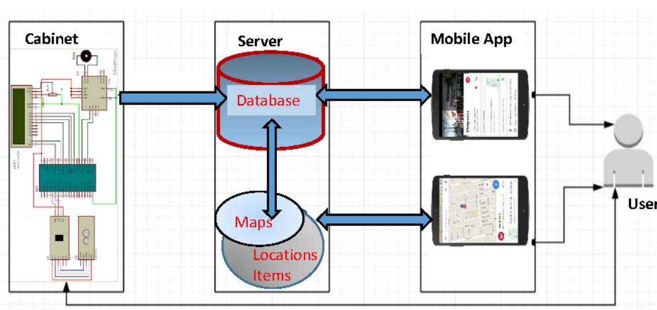


Figure 3. Main Entities and Workflow Enactments

The demonstration will provide an opportunity for the attendees to interact with the TOSNOS by presenting an actual execution of the workflow, corresponding to a scenario of two different users and three different types of items. It will aim at illustrating the basic interactions across the main system components, as illustrated in Figure 3.

The main steps of the demo that will be available for the attendees to experience are discussed below:

**(I)**: We will demonstrate the actual sensing equipment by providing a removal of three different items (soda cans, bottles of water, and candy bars). Each user will have a separate threshold for the lower-limit for the available quantities of the respective items.

**(II)**: We will show the corresponding updates done in the database, reflecting the online purchase orders for items that were removed in a manner that brought their reserves below the critical threshold after Step I. We assume, for this step, that there will be WiFi available in the demo-room. This will be done in a "before vs. after" manner, as we will show the data-status prior to executing Step I, followed by the display of the values of the data items after it.

**(III)**: For each of the users, the demo will illustrate the features of the mobile app:

III.1 – Show notification about the order-updates, and provide the user with an opportunity to confirm or reject the order.

III.2 – Upon confirmation, the mobile app will notify the users about the proximity of a store and the items with discounted prices, that happen to be some of the pending orders. For this step of the demo, we will pre-populate the data of two stores (Walgreens and Target), and will use actual locations from OpenStreet Maps.

**(IV)**: The fourth step of the demo will consist of emulating the situation of users purchasing some of the items from the corresponding stores. Upon completion of the purchase, we will demonstrate the correctness by, once again, showing the update of the status of the corresponding data-types (both the pending order, as well as the list of available items in the shelf/cupboard).

We expect that each cycle consisting of demonstrating the steps I-IV above, including the explanations and the option that the audience performs particular steps, will not take more than 10 minutes. We note that in each successive new cycle, we will give the audience an opportunity to set different values for the parameters (e.g., instead of two, the lower-limit for soda cans can be set to three; the location of the user and the distance thresholds will be changed too).

## IV. Conclusion and Future Work

Our TOSNOS system enables the users to automatically detect the changes of the values of interest in their inventory, generate orders for online purchases – and enable the users to balance the needed purchases via in-store and online mode. While providing a novel collaborative-shopping experience – TOSNOS is still "user-centered" in terms of convenience of the services that it provides. In the future, we are planning to explore the option of vendors dynamically adjusting the pricing of their products, with the awareness of the pending orders and the customers' whereabouts.

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