Smart Refrigerator

Design Review

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Statement of Needs

- The New York Times reports that an average American family of four will account for over 120 pounds of food waste per month and that 27% percent of all food available will be lost to waste [**?**]. In addition, other resources are lost due to inefficient shopping practices; forgetting common items or special trips made for recipe ingredients waste time and fuel. A system is required for shoppers both to ensure their purchases are used before expiration and to assist in planning of grocery shopping trips.

Objective Statement

- The objective of this project is to design a prototype that will allow a user to track food items in order to reduce waste and improve shopping efficiency. The system will remind the user about items nearing their expiration date and track the frequency of purchased items. From this frequency calculation the system will suggest typical shopping lists. A mobile phone application will provide an interface to the unit to view or create shopping lists and to query inventory.

Customer Needs

- The system should provide an intuitive, easy to use graphical interface.
- The system should require minimal user input.
- The system should be able to scan product codes and identify corresponding items quickly.
- The system should provide secure remote access.
- The system should report items nearing expiration.
- The system should provide access to the current inventory.
- The system should provide a method to create and edit shopping lists.
- The system should recommend shopping lists which accurately reflect buying habits.
- The system should function as an add-on to an existing refrigerator or pantry.
- The system should indicate if food products are stored safely.

Engineering Specifications

Customer Need	Engineering Requirement	Justification
2,3	A. An off-the-shelf UPC scanner should be used to input items.	A UPC scanner can read product codes with a single click.
3	B. An internal UPC code database should be used to associate codes with items.	An internal database will remove delays associated with an internet look-up.
1,4,6	C. The system should be internet enabled and provide a web interface.	By providing a web interface any other internet-connected device can access the system.
4	D. Remote access should be authenticated with user name and password.	User names and passwords are standard for access control.
⋮	⋮	⋮

Engineering Specifications

Customer Need	Engineering Requirement	Justification
2,5	E. An internal database will store default recommended expiration estimates for common categories of items.	Inferring expiration dates based on item category helps minimizes user input. It is well known how long some products take to expire.
1,5	F. The user interface will provide a method for updating default expiration estimates.	Default estimates will not account for condition of product on arrival and may need to be updated.
1,5	G. Interface will provide a visual indication to the user when items are within a user-defined margin of expiration.	The goal of the system is to reduce waste due to expiration.
⋮	⋮	⋮

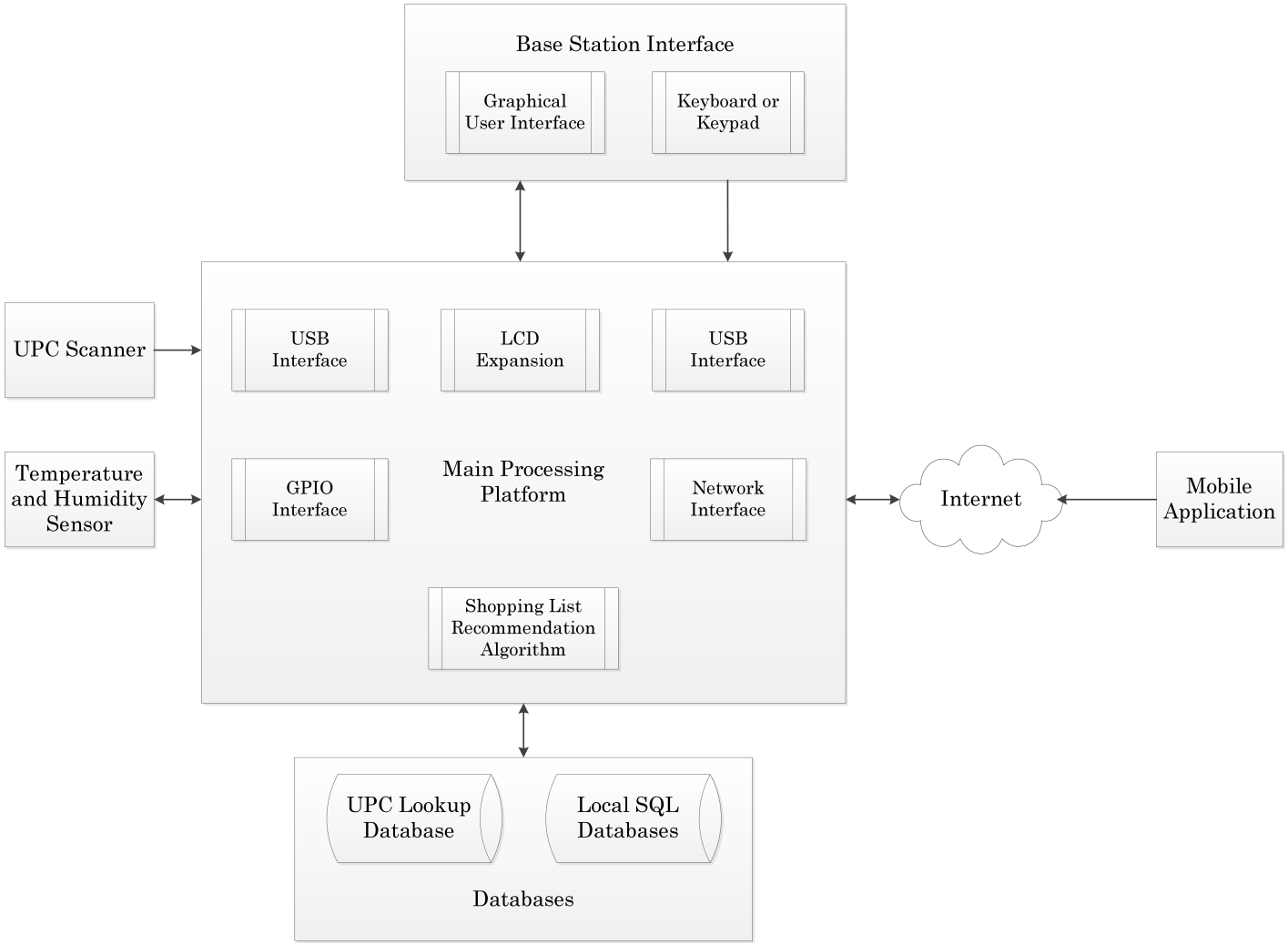
Engineering Specifications

Customer Need	Engineering Requirement	Justification
1,6	H. From both the base station and mobile application the user will be able to view an inventory list.	The user needs access to the current inventory in order to use items and shop effectively.
7,8	I. A database will be devoted to storing recommend shopping lists produced by the system.	User may wish to retain generic shopping lists for future use.
8	J. Recommended shopping lists will reflect purchasing history and expiration dates of current inventory.	Recommendation policy must suggest items relevant to the user in order to be useful.
⋮	⋮	⋮

Engineering Specifications

Customer Need	Engineering Requirement	Justification
7	K. Custom shopping lists, created either from the base station or the mobile interface, can be added to shopping list database.	Inefficient shopping practices can be prevented by storing shopping lists and the system can not anticipate all required items.
9	L. The system will be self-contained and no modifications will be required to existing appliances.	Similar systems are commercially available but require costly replacement of existing appliances.
10	M. The system should measure temperature and humidity within the refrigerator.	Temperature and humidity measurements will allow the user to determine if food storage conditions are safe.

Top Level System Diagram



Concept Selection – Processing Platform

- Brief Point One
- Brief Point Two

	Method			
	Personal Computer	Tablet (Combined UI and Processing)	Micro-controller	Beagleboard-xM
Processing Resources	+ + + +	+ +	+	+ + +
Cost	- - -	+	+ + +	+ + +
Size	- - -	+ +	+ + +	+ + +
Total	2-	5+	7+	9+

Concept Selection – Display

- Brief Point One
- Brief Point Two

	Method		
	LCD PC Monitor	Tablet	LCD with BeagleBoard-xM
Integration with Unit	- - -	-	+ + +
Ease of Use	+ + +	+ + +	+ +
Size of Display	+ + +	+ + +	+ +
GUI Quality	+ + +	+ + +	+ + +
Size of Unit	- - -	+ + +	+ + +
Total	3+	12+	13+

Concept Selection – Expiration Date Prediction System

- Brief Point One
- Brief Point Two

	Method			
	User Input of expiration dates	Image to Text Recognition	Predictive Strategy without itemMaster	Predictive Strategy with itemMaster
Ease of Use	- - -	+	+ + +	+ + +
Feasibility	+ + +	- - -	- - -	+ + +
Accuracy	+ +	+ +	+	+
Total	2+	0	4+	7+

Concept Selection – Shopping List Prediction System

		Method		
	Trial	Normal Approximation	Non-Parametric Distribution	Clustering to produce sum of Gaussians
$\sum$ Log Probability Observed Habits (Goal to Maximize)	1	-38.3394	-35.9682	-34.7721
	2	-20.5647	-17.0897	-15.6641
	3	-47.8101	-44.9658	-43.9845
	4	-29.1931	-19.6762	-24.4915
Evaluation		- - -	-	+ + +
$\sum$ Log Probability Habits Not Observed (Goal to Minimize)	1	-36.7898	-38.4187	-50.6578
	2	-188.514	-225.002	-318.926
	3	-62.2909	-63.8609	-69.9759
	4	-29.6667	$-\infty$	-86.0767
Evaluation		- - -	+	+ +
Ease of Computation		+ + +	- - -	-
Total		3-	3-	4+