USE CASE: FOOD PROVENANCE: IDENTIFYING SOURCES OF INGREDIENTS IN OUR FOOD

WEBSITE

https://tw.rpi.edu/web/Courses/Ontologies/2017/FoodProvenance

I. USE CASE DESCRIPTION

<table>
<thead>
<tr>
<th>Use Case Name</th>
<th>Food Provenance Portal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use Case Identifier</td>
<td></td>
</tr>
<tr>
<td>Source</td>
<td></td>
</tr>
<tr>
<td>Point of Contact</td>
<td>Kiana McNellis, <a href="mailto:mcnelk@rpi.edu">mcnelk@rpi.edu</a></td>
</tr>
<tr>
<td></td>
<td>Vipula Rawte, <a href="mailto:rawtev@rpi.edu">rawtev@rpi.edu</a></td>
</tr>
<tr>
<td></td>
<td>Trilce Encarnacion, <a href="mailto:encart@rpi.edu">encart@rpi.edu</a></td>
</tr>
<tr>
<td>Creation / Revision Date</td>
<td>04/28/2017</td>
</tr>
<tr>
<td>Associated Documents</td>
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</tr>
</tbody>
</table>

II. USE CASE SUMMARY

Goal

US Consumers are increasingly concerned about what is in the foods they purchase for consumption. The US diet is largely dependent on processed foods, and the lack of information about these intermediate goods needs to change. Furthermore, concerns over the health of foods - due to high amounts of processing, non-labeling of GMOs, additives, and contamination - are high, and answers are not easily found. Consumers want to be able to easily find this information and use it in planning their meals. In this research, we are interested in evaluating the use of semantic technologies to provide information about the health impacts of ingredients of processed food items found in most supermarkets, so that consumers can make an informed decision about their consumption.

Requirements

Allow input of product / barcode. Find the relevant ingredient data, or fallback to generic item. Find health concerns or disease outbreaks, associated with ingredients. Find the worldwide sources for the product & ingredient, along with any specific information provided by producer. Find the production processes associated with growing/making the good

Scope

The food provenance portal will support the search for US consumer food products - specifically branded items available in supermarkets and other retail establishments. The system will provide information about ingredient composition and manufacturing process for the food items. Based on the ingredients, the portal will report any links to adverse health effects associated with them, as well as any contamination alerts impacting the ingredients.

Priority
<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Consumers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supermarkets &amp; Restaurants – they want to provide health and environmentally-conscious customers with the best products to improve sales.</td>
<td></td>
</tr>
<tr>
<td>Food &amp; Health boards – they want to keep track of the sources of foods that people eat &amp; monitor any spikes in illness.</td>
<td></td>
</tr>
<tr>
<td>Food production companies – want to stay competitive with consumer’s demands</td>
<td></td>
</tr>
</tbody>
</table>

| Description           | Consumers and other interested parties will be able to search for relevant information about processed food items available for purchase in the US. The portal will provide data about the ingredient composition of an item. Based on this information, the system will also report on health risks associated with either the ingredient itself, or the manufacturing process used. |

<table>
<thead>
<tr>
<th>Actors / Interfaces</th>
<th>Primary: Consumers looking for information about food sourcing and health.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Primary: Food Provenance Ontology, provides sourcing information.</td>
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<tr>
<td></td>
<td>Secondary: Source of information, FDA, CDC</td>
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<tr>
<td></td>
<td>Secondary: Supermarkets &amp; Restaurants would like to provide health and environmentally-conscious customers with the best products to improve sales.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pre-conditions</th>
<th>Reporting by food companies of ingredients used.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Reporting of GMO status.</td>
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<td></td>
<td>Matching of ingredients to production methods</td>
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<td></td>
<td>Current contamination warnings</td>
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<td></td>
<td>Health impact of goods</td>
</tr>
<tr>
<td></td>
<td>Ontologies to match different forms of ingredients</td>
</tr>
<tr>
<td></td>
<td>Ontologies to match different manufacturing processes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Post-conditions</th>
<th>List of Ingredients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Associated health impacts</td>
</tr>
<tr>
<td></td>
<td>Whether it contains genetically modified organisms</td>
</tr>
<tr>
<td></td>
<td>Possible contamination and health alerts</td>
</tr>
<tr>
<td></td>
<td>Description of production method</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Triggers</th>
<th>Consumer wants to buy a product</th>
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<tbody>
<tr>
<td></td>
<td>Retailers and restaurants doing market or product research</td>
</tr>
<tr>
<td></td>
<td>Watchdog group comparing food producers practices</td>
</tr>
</tbody>
</table>

| Performance Requirements | Data should be able to be retrieved and displayed within a minute. To facilitate this, nightly/weekly data ingestions may be required. Data should be able to be added to the system routinely and reused for many queries. |

| Assumptions | Open Issues |
III. Usage Scenarios

Anna

Anna is a consumer from New Hampshire. She is an accountant and mother of 2, and wants to monitor the foods she buys. Anna wants to know what is in the food she buys, and what the effects of each ingredient are. She is interested in avoiding genetically engineered crops. To that end, she needs to find out whether GMOs are present in the ingredients of the product she is interested in purchasing. Anna inputs the product name into the Food Provenance Portal GMO search, and retrieves the list of ingredients in the product that are reported to contain GMOs, and which are certified organic.

Susan

Susan is involved in monitoring the food stocked at the supermarket to ensure that they meet sourcing requirements. She wants to avoid goods that use GMOs and antibiotics. She needs to research each new product that comes in to make sure it meets standards of not having GMO ingredients, as well as monitor previously added products to be notified of any changes. She also needs to make sure that they don’t stock products that have has recent disease outbreaks or contaminations reported. Susan uses the bulk upload of the the Food Provenance Portal, and submits a list of Unique Product Codes to be monitored. The ontology looks these codes and retrieves the information regarding ingredients, GMO reports and antibiotic protocols reported for each product.

Antonio

Antonio is a consumer concerned with additives and chemical ingredients present in the foods he consumes. Since he wants to consume mostly whole foods (with minimal additives), he is interested in researching the ingredient composition of the food items he purchases, and identifying which ingredients contain additives or added chemicals. He scans the barcode of the food product in the Food Provenance Portal, and the ontology retrieves a list of additives for the product. The ontology also does reasoning to provide reasons why each of the additives was used and any negative side effects they might have.

Martha

Martha is a consumer that is interested in healthy food items and she is concerned about negative health impacts associated with processed foods. Se would like to know what are the ingredients of the processed foods she buys and whether they pose any health risk. Martha inputs the product name into the Food Provenance Portal search, and the ontology retrieves the ingredient list, and whether any health risks are associated to them.

UPDATED USAGE SCENARIO: (Reasoning)

Priya

Priya, who has a sweet tooth and is also a healthy eating freak, visits the supermarket and comes across KEEBLER COCONUT DREAMS on the shelf and thinks if she should buy because the cookies in the picture on wrapper look tempting. As she is unsure, she quickly
opens the FP web application, scans the product barcode and gets a straight NO from the app and also receives an alternative as Kashi chocolate almond butter cookies. The reasoning is done as follows:

Priya likes chocolate+cookies and looking if it is healthy; these criteria will mapped to the ontology saying to narrow down the results to chocolate cookies which have low fat and sodium, and suggests Kashi chocolate almond butter cookies as the best result.

Lisa wants to buy packed food free from carcinogenic food ingredients but obviously cannot remember the harmful carcinogenic chemical names and their effects. Since she wants to buy Kellogg’s Froot Loops, she scans the barcode and gets the result as DO NOT BUY since it has carcinogenic food ingredients.

Kellogg’s Froot Loops has following ingredients:

- GMO sugar - GMO class
- Corn - Food additive class
- Soy Food allergen and Toxic Food ingredients class.
- The partially hydrogenated vegetable oil is GMO and contains trans fats.
- 6 artificial and natural colors on the ingredients list - Artificial flavour and color class.

We will also have a ‘Carcinogenic food ingredients’ class which will have subclasses and the reasoning will be done considering all the classes the ingredients fall into.

IV. Basic Flow of Events

Narrative: Often referred to as the primary scenario or course of events, the basic flow defines the process/data/work flow that would be followed if the use case were to follow its main plot from start to end. Error states or alternate states that might occur as a matter of course in fulfilling the use case should be included under Alternate Flow of Events, below. The basic flow should provide any reviewer a quick overview of how an implementation is intended to work. A summary paragraph should be included that provides such an overview (which can include lists, conversational analysis that captures stakeholder interview information, etc.), followed by more detail expressed via the table structure. In cases where the user scenarios are sufficiently different from one another, it may be helpful to describe the flow for each scenario independently, and then merge them together in a composite flow.

### Basic/NORMAL FLOW OF EVENTS

<table>
<thead>
<tr>
<th>Step</th>
<th>Actor (Person)</th>
<th>Actor (System)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Consumer</td>
<td></td>
<td>Accesses Food Provenance Portal</td>
</tr>
<tr>
<td>2</td>
<td>Consumer</td>
<td></td>
<td>User inputs either: Barcode, Product Name or Product Description.</td>
</tr>
<tr>
<td>3</td>
<td>Food Provenance Portal, data sources</td>
<td></td>
<td>Retrieves ingredients data from data sources</td>
</tr>
</tbody>
</table>
and services

<table>
<thead>
<tr>
<th>Step</th>
<th>Actor (Person)</th>
<th>Actor (System)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Consumer</td>
<td>Food Provenance Portal, data sources and services</td>
<td>Ontology does reasoning to provide health impacts and usage information for additives.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Food Provenance Portal, data sources and services</td>
<td>Reasoning is used to find similar products with better health or organic characteristics.</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Food Provenance Portal</td>
<td>Applies semantic reasoning to infer missing sourcing information and health impacts</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Food Provenance Portal</td>
<td>Displays results and comparisons among similar products based on their properties.</td>
</tr>
</tbody>
</table>

V. Alternate Flow of Events

**Narrative:** The alternate flow defines the process/data/work flow that would be followed if the use case enters an error or alternate state from the basic flow defined, above. A summary paragraph should be included that provides an overview of each alternate flow, followed by more detail expressed via the table structure.

<table>
<thead>
<tr>
<th>Basic/Normal Flow of Events</th>
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</thead>
<tbody>
<tr>
<td><strong>Step</strong></td>
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<tr>
<td>1</td>
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<td>2</td>
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<td>3</td>
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<td>4</td>
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<tr>
<td>5</td>
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<tr>
<td>6</td>
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</tbody>
</table>

VI. Use Case and Activity Diagram(s)

*Provide the primary use case diagram, including actors, and a high-level activity diagram to show the flow of primary events that include/surround the use case. Subordinate diagrams that map the flow for each usage scenario should be included as appropriate.*
Primary use case diagram:

Usage scenario 1:
Access Food Provenance Portal

Inputs product name into portal's GMO search

Reasoning and inferring

Displays whether product contains GMOs

Food Provenance Portal

Food Provenance Ontology

Data Source

Anna
Usage scenario 2:
Usage scenario 3:

1. **Antonio - Consumer**
   - Scans Barcode or product name
   - Access Food Provenance Portal
   - Displays additives and added chemicals per ingredient

2. **Food Provenance Portal**
   - Connected to Food Provenance Ontology
   - Connected to Data Source

3. **Food Provenance Ontology**
   - Connected to Data Source
Usage scenario 4:

- Access Food Provenance Portal
- Inputs Product Name
- Reasoning and Inferring
- Displays health risks per ingredient
- Food Provenance Portal
- Food Provenance Ontology
- Data Source

Martha - Consumer
Activity Diagram:

1. Submit Barcode
2. Find
3. Find
4. Product ingredients
5. Nutritional information
6. Find
7. Ingredient health hazard
8. Result
9. Display Result
Usage scenario Alternate Flow:

VII. COMPETENCY QUESTIONS

Provide at least 2 competency questions that you will ask of the vocabulary/ontology/knowledge base to implement this use case, including example answers to the questions.

EXAMPLE QUESTIONS

For answering all the below competency questions, the Food Provenance ontology (developed using original concepts as well as importing some available ontologies like the Bio-Portal Food ontology, DBpedia, etc) will be used which will have different classes for food ingredients, additives, artificial color and flavor, food allergen, GMO content, health impact and others (TBD), subclasses, data and object properties.
**UPDATED COMPETENCY QUESTIONS**

**Question 1:** What are the potential health hazards associated with Mars M&M candies?

```sql
select DISTINCT ?HealthHazard
where
{

  {
    fp-ind:Red40 fp:hasHealthHazard ?HealthHazard.  
  }
union
  {
    fp-ind:Yellow5 fp:hasHealthHazard ?HealthHazard.  
  }
union
  {
    fp-ind:Yellow6 fp:hasHealthHazard ?HealthHazard.  
  }
union
  {
    fp-ind:Blue1 fp:hasHealthHazard ?HealthHazard.  
  }
union
  {
    fp-ind:Blue2 fp:hasHealthHazard ?HealthHazard.  
  }
}
```

Explanation
MarsMM Milk Chocolate candies is a Food
and hasIngredient Additive
which has subclass ColorAdditive
which has subclass CertifiedColor
which has instances Blue1, Blue2, Red40, Yellow5 and Yellow6 found in US M&M
and these instances have hasHealthHazard ChromosomalDamage, BrainTumor, Lymphomas, Hyperactivity, Asthma, Insomnia, Aggression, ThyroidTumor
and thus M&M candies can lead to the following Health Hazards.

Answer:
HealthHazard
1
fp-ind: Hyperactivity
2
fp-ind: ChromosomalDamage
3
fp-ind: Lymphomas
4
fp-ind: ViolentBehavior
5
fp-ind: Aggression
6
fp-ind: ThyroidTumor
7
fp-ind: Insomnia
8
fp-ind: NeurochemicalAndBehavioralEffects
9
fp-ind: Asthma
10
fp-ind: Eczema-Hives
11
fp-ind: BrainTumor

Question 2: What are the likely health hazards associated with Healthy Choice Chicken Noodle Soup?
prefix fp: <http://tw.rpi.edu/web/Courses/Ontologies/2017/FoodProvenance/FoodProvenance/>
prefix fp-ind:
<http://tw.rpi.edu/web/Courses/Ontologies/2017/FoodProvenance/FoodProvenance_Individuals/>
prefix rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
prefix owl:<http://www.w3.org/2002/07/owl#>

select DISTINCT ?HealthHazard
where {
  fp-ind:HealthyChoiceChickenNoodleSoup fp:hasIngredient ?Ingredient1.
  ?Ingredient1 fp:hasIngredient ?Ingredient2.
}

Explanation
(Usage of Transitivity of object property:hasIngredient is shown in this example)
Healthy Choice Chicken Noodle Soup is a Food
and hasIngredient Additive
  which has subclass FlavorAdditive
  which has subclass FlavorEnhancer
  which has instances AutolyzedYeastExtract found in Healthy Choice Chicken Noodle Soup
and this instance further has hasIngredient MonoSodiumGlutamate
  which has hasHealthHazard Headache, Eczema, WeaknessOfArmsOrLegs,
  BurningSensationOfMouthHeadNeck
and thus Healthy Choice Chicken Noodle Soup can lead to the following Health Hazards.

Answer:
HealthHazard
1
fp-ind:Eczema-Hives
2
fp-ind:WeaknessOfArmsOrLegs
3
fp-ind:BurningSensationOfMouthHeadNeck
4
fp-ind:Headache

Question 3: Is Coca-Cola's DIET BARQ safe to consume and what is the healthy alternative, if available?
prefix fp: <http://tw.rpi.edu/web/Courses/Ontologies/2017/FoodProvenance/FoodProvenance/>
prefix fp-ind:
select DISTINCT ?HealthHazard ?HealthyAlternative
where
{
{
  fp-ind:CocaCola fp:hasMajorIngredient fp-ind:HighFructoseCornSyrup .
  fp-ind:HighFructoseCornSyrup fp:hasHealthHazard ?HealthHazard .
}
UNION
{
  fp-ind:CocaCola fp:hasHealthyAlternative ?HealthyAlternative
}
}

**Explanation**
CocaCola is a Food
It hasMajorIngredient HighFructoseCornSyrup
Which hasHealthHazard cardiovascular disease
And thus is not safe

**Answer:**
HealthHazard
1
fp-ind:Obesity
2
fp-ind:CardiovascularDisease
3
fp-ind:Asthma

HealthyAlternative
4
fp-ind:PerrierPinkGrapefruitSparklingNaturalMineralWater

**Question 4:** Does Kellogg’s Corn Flakes contain possible carcinogenic ingredient and what, if yes?

prefix fp: <http://tw.rpi.edu/web/Courses/Ontologies/2017/FoodProvenance/FoodProvenance/> prefix fp-ind:
Kellogg’s Corn Flakes is a Food and hasIngredient Preservative with instances Butylated Hydroxytoluene (BHT) which is also an instance of CarcinogenicIngredientToAvoid which is a subClassOf HarmfulIngredient and thus Kellogg’s Corn Flakes is categorized as NOT safe to consume.

Answer:
Ingredient
1
fp-ind:ButylatedHydroxytoluene

IngredientType
fp:CarcinogenicIngredientToAvoid

Question 5: Does Kraft Mac & Cheese contain milk allergy related ingredient?
Explanation
Kraft Mac & Cheese is a Food
and hasMajorIngredient CheeseSauceMix
which hasIngredient Milkfat
which hasAllergenMilk
and thus is categorized as a Milk Allergen

Answer:
MajorIngredient
1
fp-ind:CheeseSauceMix-KraftMacaroniAndCheese

Ingredient
fp-ind:MilkFat

DoesItHaveAllergenMilk
"true"^^xsd:boolean

VIII. Resources
In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include the set of actors listed above, with additional detail, and any other ancillary systems, sensors, or services that are relevant to the problem/use case.

<table>
<thead>
<tr>
<th>Name</th>
<th>Category</th>
<th>Description</th>
<th>Link</th>
<th>Secondary</th>
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</thead>
<tbody>
<tr>
<td>Open Food Facts</td>
<td>Database</td>
<td>Crowd sourced food facts</td>
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</tr>
<tr>
<td>USDA Branded Food Products</td>
<td>Database</td>
<td>api, ingredients and nutrition of foods</td>
<td><a href="https://ndb.nal.usda.gov/ndb/api/doc">https://ndb.nal.usda.gov/ndb/api/doc</a></td>
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<tr>
<td>Database</td>
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<tr>
<td>Food additive</td>
<td>Database</td>
<td>list of additives and</td>
<td><a href="https://www.fda.gov/Food/IngredientsP">https://www.fda.gov/Food/IngredientsP</a></td>
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<td>ackagingLabeling/FoodAdditivesIngredients/ucm091048.htm</td>
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**IX. REFERENCES AND BIBLIOGRAPHY**

List all reference documents – policy documents, regulations, standards, de-facto standards, glossaries, dictionaries and thesauri, taxonomies, and any other reference materials considered relevant to the use case


X. Notes

There is always some piece of information that is required that has no other place to go. This is the place for that information.