Summary of a Citywide Meal Planning Service for Kids based on Logic Programming

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Introduction (1/2)

Right to food: legally binding human right in international laws

- *International Covenant on Economic, Social and Cultural Rights* (*ICESCR*), adopted by the United Nations General Assembly on December 16^{th}, 1966

Malnutrition: pathological state resulting from inadequate nutrition (the nutritional needs of the organism are not met)

- Quality of food (deficiency of one or more nutrients)
- Quantity of food (excess or defect of food)

To combat malnutrition: propose tools designed to instill in each individual, from childhood, a correct diet associated with a healthy lifestyle

Introduction (2/2)

Meal planning: the organization and in-advance planning of the meals that will be consumed by an individual within a single day, a week, or a month

Purpose of meal planning: nutritionally balance various meals to respect a correct distribution of the macronutrients (i.e., *carbohydrates*, *proteins*, and *lipids*)

Meal planning support tools: Web-based solutions or mobile apps

NUBI (NUtrizione BImbi): service and associated mobile app designed to complement the service offered by the school canteens of nurseries, kindergartens, and primary schools of the municipalities of Parma (NUBI Parma)

NUBI (1/4)

A joint effort of

- The *Artificial Intelligence Laboratory* of the University of Parma
- The *Department of Food and Drug* of the University of Parma
- *MADEGUS S.R.L.* (`www.madegus.com`), a spin-off company of the University of Parma

A service, co-financed by the municipalities of *Parma* and of *Reggio Emilia*, made available to families in the form of a mobile app for *Android* and *iOS* since the end of 2016

App Android

App iOS

NUBI (2/4)

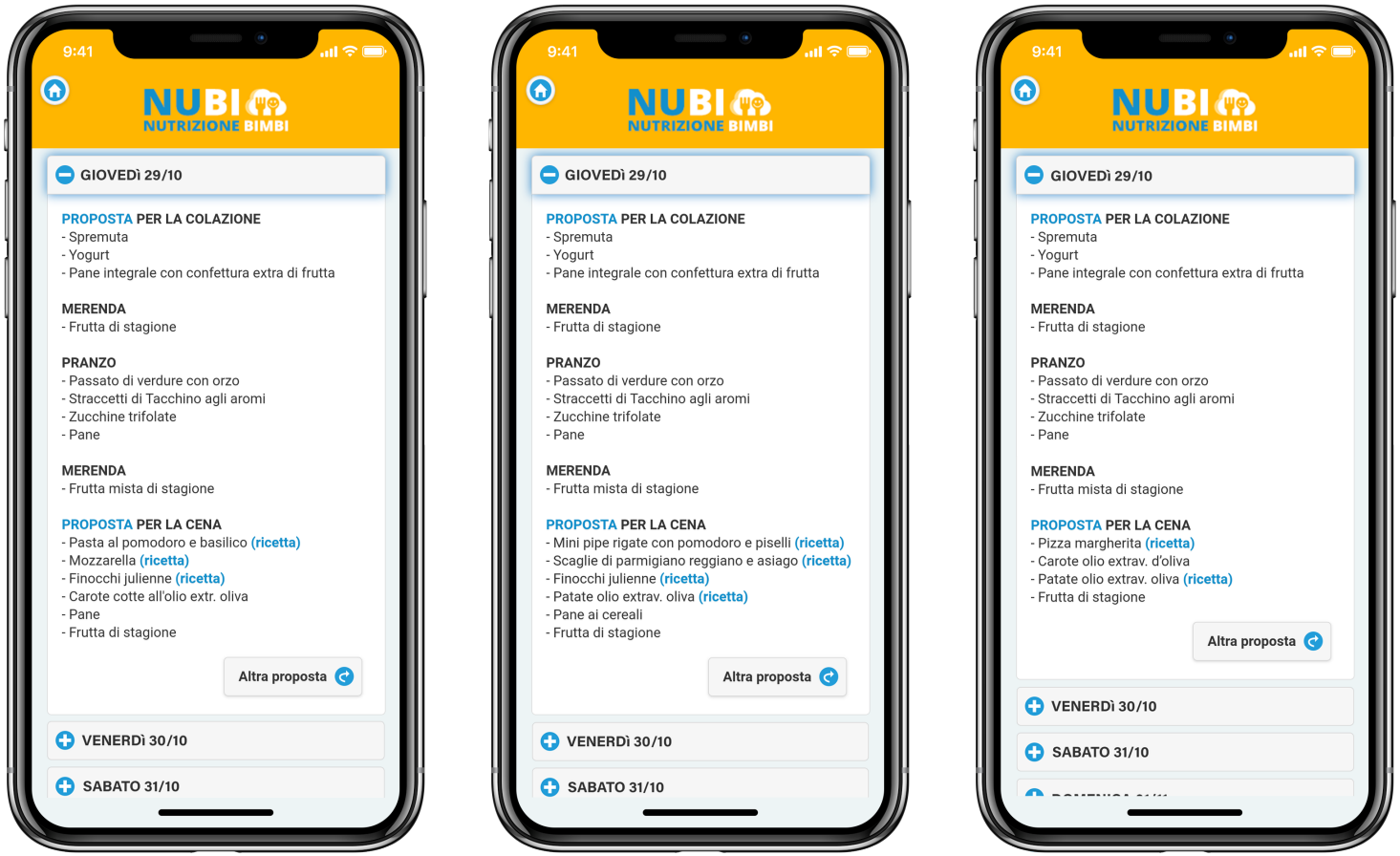
NUBI was created to give concrete help to families to offer a healthy and balanced diet to children

Goals

- Assist parents in the choice and in the preparation of nutritionally balanced dinners and non-school day lunches
- Promote correct and balanced eating behaviors in a simple and intuitive way
- Target health problems associated with malnutrition

NUBI (3/4)

Three dinner proposals are offered for every evening to nutritionally balance the lunch eaten at school, with accompanying recipes, and for the whole week



NUBI (4/4)

In addition to dinner proposals, non-school day lunch proposals are provided

The menus provided by the app

- Guarantee nutritionally balanced menus
- Provide seasonal proposals (fruit and vegetables)

The app has a solid user base

- More than 136 034 requests from users in the school year 2018/2019 (last school year before the COVID-19 pandemic)
- More than 18 193 active mobile devices from the end of 2016
- More than 558 451 requests for weekly menus from the end of 2016

Lunch and Dinner Menus

Problem

- *NUBI menus* include the lunches offered by the canteen services, the non-school day lunches, and the dinner proposals
- NUBI menus were initially produced *manually* at the beginning of every school year

Goal

- Describe the problem of generating non-school day lunches and dinner proposals as a *Constraint Satisfaction Problem (CSP)* on finite domains
- Implement a dedicated solver to automatically generate NUBI menus using available menus of canteen services and adopted nutritional constraints

Background Knowledge

The background knowledge needed to deliver the NUBI service is immersed in a set of documents available from the Department of Food and Drug of the University of Parma

The documents describe nutritional constraints, recommended by major international institutions, that must be respected for each meal within a week or a month, also taking into account regionality and seasonality of dishes

Such documents contain

- A list of dishes split into categories and sub-categories
- The yearly menus offered by the canteen services of nurseries, kindergartens, and primary schools of the municipality of Parma
- An informal description of nutritional constraints

Usable Dishes Table

A database table containing over 300 dishes that can be used for lunches (school days or not) and for dinners, described by 37 columns

- 2 columns to store the numeric identifier and the name of the dish
- 10 columns that associate each dish to at least one of 10 classes, e.g., *for breakfast*, *side dish*, and *dessert*
- 7 columns that list the major sources of proteins in each dish, e.g., *white meat*, *fish*, and *legumes*
- 5 columns that list the major sources of carbohydrates in the dish, e.g., *pasta*, *rice*, and *tubers*
- 2 columns that describe the characteristics of the dish, relevant only when the dish is marked as vegetable

School Lunch Table

A database table containing the lunches offered by the canteen services of nurseries, kindergartens, and primary schools of the municipality of Parma (extended every school year)

id	date	meal_type	school_type	dish_id_1	dish_id_2	dish_id_3	dish_id_4	dish_id_5	dish_id_6	dish_id_7	dish_id_8	dish_id_9	dish_id_10
113	28/09/2020	l	ni	310	747	801	400	708	362	431			
117	29/09/2020	l	ni	353	379	334	401	362	337				
121	30/09/2020	l	ni	351	804	330	326	362	342				
125	01/10/2020	l	ni	352	704	421	433	362	337				
129	02/10/2020	l	ni	429	376	710	709	362	423				
141	05/10/2020	l	ni	353	803	93	325	362	337				
145	06/10/2020	l	ni	432	711	327	312	362	423				
149	07/10/2020	l	ni	342	376	707	746	362	337				
153	08/10/2020	l	ni	350	725	396	729	362	341				
157	09/10/2020	l	ni	352	830	412	401	362	430				
169	12/10/2020	l	ni	429	701	335	401	362	342				
173	13/10/2020	l	ni	351	702	302	326	362	337				
177	14/10/2020	l	ni	353	812	422	433	362	713	431			
181	15/10/2020	l	ni	351	747	706	729	362	337				
185	16/10/2020	l	ni	310	806	332	325	362	423				
197	19/10/2020	l	ni	432	411	361	729	362	337				
201	20/10/2020	l	ni	350	151	820	746	362	341				
205	21/10/2020	l	ni	352	372	726	325	362	430				
209	22/10/2020	l	ni	342	150	389	326	362	423				
213	23/10/2020	l	ni	353	705	319	401	362	337				

Constraints (1/4)

The reference documents provided by the Department of Food and Drug of the University of Parma contain an informal description of a set of nutritional constraints that must be respected in the composition of non-school day lunches and dinner proposals

Types of constraints

- Constraints on the three types of meal offered in the menus
- Compatibility constraints associated with food categories and subcategories
- Constraints for each food subcategory on the maximum frequency of weekly, daily, and per-meal use

Constraints (2/4)

Constraints on the three types of meal offered in the menus

- *Regular meals*, consisting of
  - First dish (carbohydrates)
  - Second dish (proteins)
  - Side dish (vegetables)
  - Bread
  - Fruit
- *Semi-single meals*, consisting of
  - Semi-single dish
  - Semi-single side dish
  - Bread
  - Fruit
- *Single meals*, consisting of
  - Single dish
  - Side dish (vegetables)
  - Fruit

Constraints (3/4)

Compatibility constraints associated with food categories and subcategories

- Dishes marked as containing carbohydrates and proteins cannot be present in a semi-single meal
- Dishes marked as containing carbohydrates, proteins, and bread cannot be present in a single meal
- . . . many other constraints

Constraints on the composition of dinner proposals

- Three dinner proposals must be available for every evening except for the evenings of non-school days
- The three dinner proposals must consist of two regular meals and one single or semi-single meal
- . . . a few other constraints

Constraints (4/4)

Constraints on the maximum frequency for each food subcategory of weekly, daily, and per-meal use (fragment)

Food category	Food subcategory	Maximum weekly	Maximum daily	Maximum in meal
Carbohydrates	Pasta	7	1	1
	Rice	4	1	1
	Tubers	4	1	1
	Soups	4	1	1
	Cereals	6	1	1
Proteins	White meat	2	1	1
	Red meat and cured meat	2	1	1
	Fish	3	1	1
	Dairy products	3	1	1
	Eggs	2	1	1
	Legumes	4	1	1
	Protein mix	2	1	1
Special dish	Single	7	2	1
	Semi-single	7	2	1
Vegetables	Raw	14	2	1
	Cooked	14	2	1
	For semi-single	14	1	1

Relaxable Constraints

Problem: meal planning problems are often unsolvable because the set of usable dishes is not sufficient to satisfy all constraints

Relaxable constraints: the values of the parameters that characterize some constraints can be changed with no severe impact on the nutritional quality of menus

Constraints identified as relaxable

- Maximum number of dishes marked as fish per week, which can be increased, if needed, from 3 to 4
- Maximum number of dishes marked as legumes per week, which can be increased, if needed, from 4 to 5

Meal Planning Problems as CSPs

Meal planning problem as a CSP on finite domains

- A year is split into quarters with associated dishes
- A quarter is split into months because a few constraints are are monthly
- Weeks are treated independently and monthly constraints are verified *a posteriori*

For each meal in a week

- Variables: the ten dishes that are possibly needed

$$V = \{dish\_id\_1, dish\_id\_2, \ldots, dish\_id\_9, dish\_id\_10\}$$

- Domains: IDs of the dishes available in the dishes table

$$dom(dish\_id\_1) = \ldots = dom(dish\_id\_10) = \{IDs\ from\ the\ dishes\ table\}$$

- Constraints: nutritional constraints that must be respected in the week

Conclusions

Obtained results

- An algorithm to build a constraint satisfaction problem from a given weekly meal planning problem
- A software system to produce monthly menus satisfying nutritional constraints ($\leq$ 100ms on an ordinary laptop)

Short term developments target the production of customized menus based on

- User preferences and habits
- Allergies and special diets (medical or cultural)
- Shopping lists and readily available ingredients (possibly integrated with a delivery service)

Thank You for Your Attention

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NUBI

App Android

App iOS

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