Ontology-Based Food Recommender System for Nutrition in School-Age

**Dinda Atikah Wulandari[1), Z. K. A. Baizal[2)*

[1,2)School of Computing, Telkom University, Indonesia
[1)Dindaatikahwulandari@student.telkomuniversity.ac.id, [2)baizal@telkomuniversity.ac.id

Abstract: Nutrition plays an important role in the body and child development. Therefore, it is very important for parent to understand the nutritional needs of children to grow healthy and smart. If nutritional intake is not met, malnutrition can occur in children it interferes whit their growth and development process. The food recommendation system in this study is based on knowledge modeling. The focus of the research is to develop a recommendation system using ontology with Semantic Web Rule Language (SWRL) and form a knowledge base according to the guidelines proposed by Recommended Nutrient Intakes (RNI). Additionally, an Artificial Intelligence (AI) telegram chatbot named NutritionChildreBot was developed for this purpose. The recommended food menu is following the nutritional needs of children aged 7-9 years. The acquired knowledge base will be managed to provide information to users. The results of this research evaluation are in the form of recommendations for selecting foods that meet children's nutritional needs based on information obtained from reliable sources.Based on this value, the calculation of precision, memory, and F_Score obtained is 97,9% of the accuracy of the results recommended by the system.

Keywords: Recommender System, Ontology, Food Recommender System, Child Nutrition.

INTRODUCTION

Children aged 7-9 years are in a developmental phase called the golden age. Children at this age experience physical, cognitive, psychological, and language development at this age.Numerous elements influence the process of growth and maturation.Nutrition is among the elements that impact the growth and development of individuals(Rahmi et al., 2019).It is very important to know the nutritional needs of children to grow healthy and smart. If nutritional intake is not met, then malnutrition will occur in children and will interfere with the process of growth and development in children. According to the Nutrition Adequacy Rate (RDA) from the Indonesian Ministry of Health, children aged 7-9 years need daily nutrition such as protein, fat, carbohydrates, fiber, water, vitamins, and minerals. Therefore, it is necessary to have certain interventions to manage these nutritional needs. One strategy is to recommend a balanced nutritional daily diet. Nutritional recommendations should be based on scientific observations in terms of cultural and social status and beliefs.School-age children need the role of parents in regulating their eating habits. Effecting direct changes in a child's eating habits and weight can prove to be challenging. However, parental feeding practices present an opportunity for interventions aimed at discouraging unhealthy eating patterns and fostering balanced weight development in children(Finnane et al., 2017).

Ontologies are representations of knowledge that are possible in information systems on the Semantic Web as well as in other fields. It formulates a subject area using a language that is

comprehensible to both humans and machines, encompassing entities, attributes, relationships, and statements(Sambola et al., 2021). A recommendation system is a software application capable of suggesting products or services based on user preferences, while also engaging in interactions with users(Zhang et al., 2015). This study involves the creation and development of a recommender system ontology model within the semantic web context, specifically focusing on nutrition in relation to school-age children. Semantic technology has been incorporated into this research to offer precise representations that define concepts like food allergies, ingredients, and recipes within this specific field(Sambola et al., 2021). Through reasoning methods, the system deduces the user's state of health and provides suitable suggestions for food choices.

LITERATURE REVIEW

Nutrition is a word that means healthy food (Rahmi et al., 2019). Nutrients are contained in the intake of food consumed every day. However, not all foods consumed contain the nutrients needed by the body. The process of growth and development in children requires healthy and harmless nutrition. Numerous foods present in a child's surroundings contain components unnecessary for the body, including preservatives, synthetic colorings, artificial sweeteners, and substances that can adversely affect the child's physical well-being, potentially hindering their growth and developmental progress.

During early childhood, often referred to as the golden age, rapid human growth and development take place due to a variety of influential factors. Among these factors, nutrition plays a significant role in shaping human growth and development(Rahmi et al., 2019). It is very important to know the nutritional needs of children to grow healthy and intelligent. If nutritional intake is not met, malnutrition will occur in children and will interfere with the process of growth and development in children.

One factor causing children's malnutrition is unfavorable socio-economic conditions, often considered the biggest factor causing not optimal growth in a child's body (Artaria et al., 2009). The growth and development of children are influenced by many things, including genetic factors (heredity), good psychological conditions, a stable political situation in the country of residence, health conditions, the number of family members living in one house, etc. (Bogin et al., 1997).

According to the Nutrition Adequacy Rate (RDA) from the Indonesian Ministry of Health, children aged 7-9 years need daily nutritional intake such as protein, fat, carbohydrates, fiber, water, vitamins, and minerals. Therefore, it is necessary to have certain interventions to manage these nutritional needs. One strategy is to recommend a balanced nutritional diet. Nutrition recommendations should be based on scientific observations in terms of culture and social status, and beliefs. The Recommended Dietary Allowance (RDA) for the Indonesian population signifies a benchmark indicating the average daily nutrient requirements that should be fulfilled based on specific criteria such as age, gender, physical activity level, and physiological state to promote a healthy lifestyle (Indonesia et al., 2019). Table 1 outlines the nutritional necessities for children aged 7-9 years.

Table 1. Adequacy Recommended of Energy, Protein, Fat, Carbohydrate, Fiber, and Water (per person per day) (AsDI., 2014)

Age Group	Weight (kg)	Height (cm)	Energy (kcal)	Protein (g)	Carbo (g)	Fat (g)	Serat (g)	Water (ml)
7-9 years	27	130	1650	40	250	55	23	1650

Sambola researched dietary recommendations for diabetic patients by building an ontology-based dietary recommendation system for diabetic patients. The constructed system solely considers factors such as Body Mass Index (BMI), age, weight, and height when dealing with individuals who are overweight(Sambola et al., 2021). A recommendation system is a software application designed to suggest the most appropriate products or services to specific users, whether individuals or businesses.

*name of corresponding author

This is achieved by forecasting user interest in an item through the analysis of relevant details about the user, the item itself, and the interactions between the user and the item(Zhang et al., 2015).

The purpose of creating a recommendation system is to alleviate the burden of information overload by extracting the most pertinent information and services from extensive datasets, thereby delivering tailored experiences. The key attribute of a recommender system lies in its capacity to anticipate a user's inclinations and preferences. This is accomplished by analyzing user behaviors, as well as the behaviors of other users, to generate customized suggestions(Zhang et al., 2015).

The origin of the term 'ontology' can be traced back to the Greek words 'ontos' and 'logos'. In the realm of computer science, ontology is defined as 'an explicit specification of a conceptualization'. This signifies that an ontology provides a precise delineation of a conceptual framework. In the context of computer science, ontology serves as a method to distinctly portray a knowledge domain concerning a concept. This involves attributing significance, attributes, and relationships to the concept, thereby aggregating it within a knowledge realm and establishing a foundational knowledge repository(Fensel et al., 2005).

The World Wide Web Consortium (W3C) organization has endorsed specific languages for constructing ontologies. These languages encompass RDF (Resource Description Framework) and OWL (Web Ontology Language), both of which utilize XML (Extensible Markup Language) as the foundational syntax for coding. RDF is employed for defining web resources in a triple format (subject-predicate-object), whereas OWL is employed to offer more intricate statements. When it comes to retrieving web resources, queries can be formulated utilizing the SPARQL language (SPARQL Protocol and RDF Query Language) (Web et al., 2004).

The Semantic Web is widely acknowledged as a potent framework for augmenting the accessibility of knowledge on the internet. At the core of the Semantic Web lies ontology, a tool employed to precisely illustrate conceptual frameworks. In the context of the Semantic Web, ontology construction is chiefly facilitated by languages like RDF (Resource Description Framework), RDFS (Resource Description Framework Schema), and OWL (Web Ontology Language) (Ding et al., 2007). The diagram illustrating the structure of the Semantic Web is presented in Figure 1.
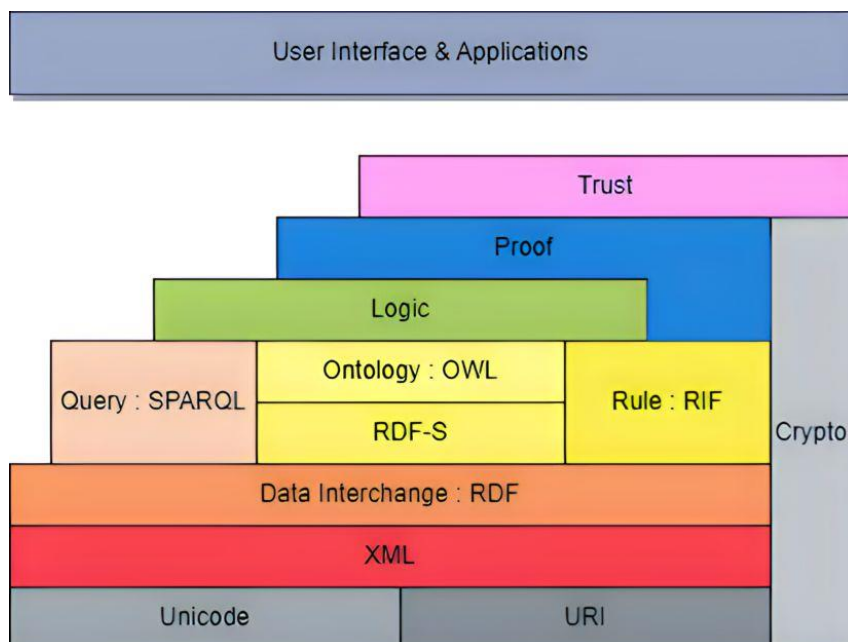

Fig 1. Structure of the semantic web (Berners et al., 2001)

METHOD

System Design

Figure 3 depicts the sequential actions involved in constructing a recommendation system based on a semantic web ontology model, which offers suggestions for nutritional food choices tailored to school-age children. The process comprises multiple phases, starting with the acquisition of individual data such as weight, age,height, gender, and physical activity level. Subsequently, the semantic web ontology is fashioned using this user data. The system's outcomes are then subjected to validation using data supplied by a nutritionist, an expert capable of recommending appropriate foods for the users.
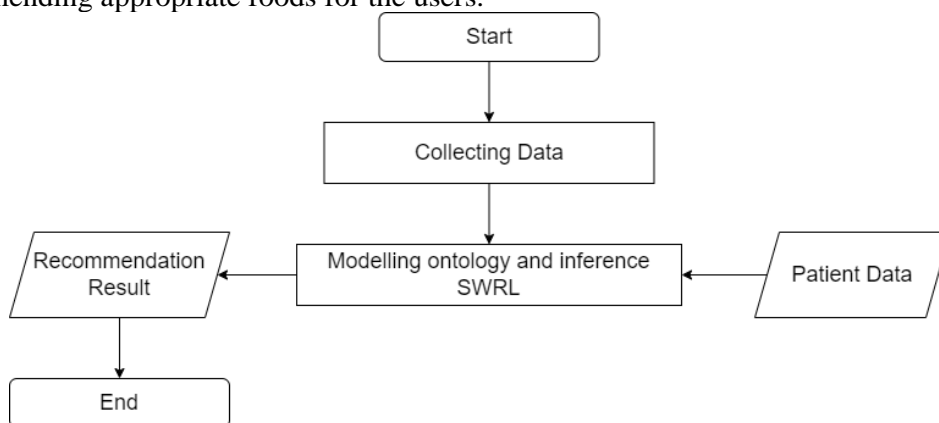

Fig 3. System Flow

Ontology Design

Figure 4 is an ontology design for a food selection recommendation system for nutrition in school-age children. There are four main classes in the ontology, namely person, Menu, Type, and BMI_Level. The person class is a class of user information that must be considered whatever is needed. Menu class for storing food information. The Type class is used to sort out foods that have allergies. Then the BMI_Level class focuses on all body masses, namely underweight, overweight, obese, and normal.
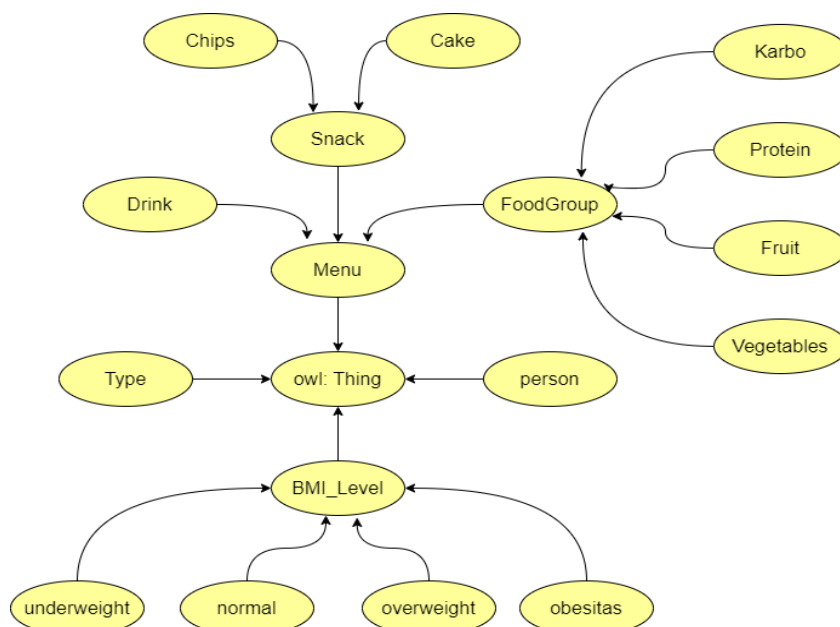

Fig 4. Ontology Design

Application of SWRL and Ontology

In this research, the ontology construction was facilitated using Protégé version 5.6.1. The approach employed was a top-down or tree methodology, which entails establishing a class, followed by sub-classes, and concluding with instances. The resulting classification hierarchy is visually represented in Figure 5.
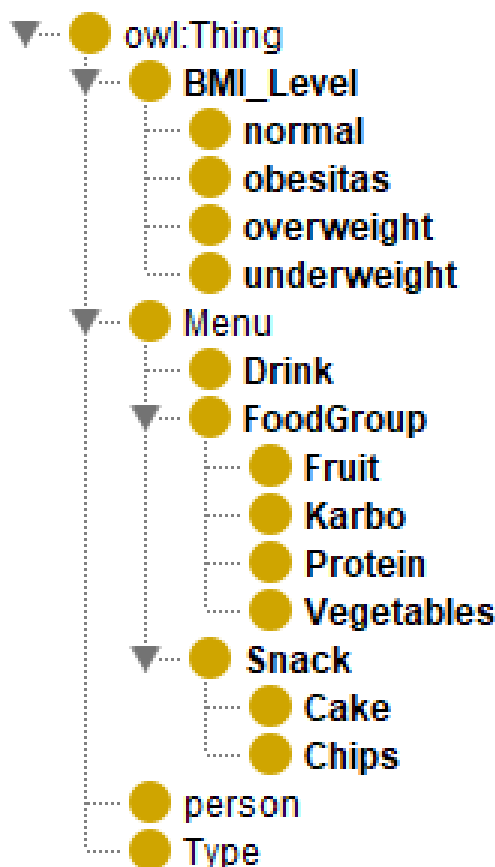

Fig 5. Class hierarchy in ontology

Every attribute serves a distinct purpose. For instance, within the 'class menu', there exists a attribute responsible for calculating the required amount of food based on the requirements of the household.Each class in the ontology has a Data Property and an Object Property. This Data property serves to complete the information of each class. Object properties are also defined to link between instances of each class through semantic relationships. The data properties and object properties used to create hierarchies and conceptual relationships between examples are shown in Table 2.

Table 2. Object Propertiesand Data Properties

Object Property	Data Property
Contains	BFCalorie
isNotContains	Description
hasBreakfastMenu	hasActivity
hasDinnerMenu	hasAge
hasLunchMenu	hasAlergi
hasSnackA	hasBMI
hasSnackB	hasBMR
hasSnackC	hasHeight
LevelNutrient	hasMenu

hasDrink	hasName
	hasGender
	hasNutrientCal
	hasNutrientCarbo
	hasNutrientFat
	hasNutrientProtein
	hasServingSize
	hassize
	haswater
	hasweight
	LunchCal
	SnackCal
	DinnerCal
	hasCalorieNeed

Below are a few SWRL rules required for generating food recommendations based on user information.

- hasBMI: A attribute that computes an approximation of body fat utilizing weight and height measurements. This research incorporated four distinct BMI classifications: normal, overweight,underweight, and obesity.
  DataPerson(?dp) ^HasWeight(?dp, ?hw) ^ HasHeight(?dp, ?hh) ^multiply(?wh, ?hw, 10000) ^multiply(?hm, ?hh, ?hh) ^ divide(?BMI, ?wh, ?hm) ->HasBMI(?dp, ?BMI)

- hasBMRfor Male
  DataPerson(?dp) ^ HasWeight(?dp, ?hw) ^ HasHeight(?dp, ?hh) ^ HasAge(?dp, ?ha) ^ HasGender(?dp, "Laki-Laki") ^ multiply(?k, ?hw, 13.75) ^ multiply(?l, ?hh, 5.003) ^ multiply(?m, ?a, 6.755) ^ add(?h1, ?k, 66.47) ^ add(?h2, ?h1, ?l) ^ subtract(?BMR, ?h2, ?m) ->HasBMR(?dp, ?BMR)

- hasBMRfor Female
  DataPerson(?dp) ^ HasWeight(?dp, ?hw) ^ HasHeight(?dp, ?hh) ^ HasAge(?dp, ?ha) ^ HasGender(?dp, "Wanita") ^ multiply(?k, ?w, 9.563) ^ multiply(?l, ?h, 1.850) ^ multiply(?m, ?a, 4.676) ^ add(?h1, ?k, 655.1) ^ add(?h2, ?h1, ?l) ^ subtract(?BMR, ?h2, ?m) ->HasBMR(?dp, ?BMR)

There are some differences in recommending foods according to the needs of fat, protein, and carbohydrates. Underweight requires high fat and protein compared to overweight and obesity.

- High Fat
  MenuMakanan(?mn) ^HasNutrientFat(?mn, ?nu) ^ divide(78, ?h, ?nu) ^ multiply(100,?h, ?DV) ^greaterThanOrEqual(20, ?DV) ->LvlNutrient(?mn, HighFats)

- High Protein
  MenuMakanan(?mn) ^HasNutrientProtein(?mn, ?nu) ^ divide(50, ?h, ?nu) ^ multiply(100,?h, ?DV) ^greaterThanOrEqual(20, ?DV) ->LvlNutrient(?mn, HighProtein)

- Low Carbo
  MenuMakanan(?mn) ^HasNutrientCarbo(?mn, ?nu) ^ divide(300, ?h, ?nu) ^ multiply(100, ?h, ?DV) ^greaterThanOrEqual(?DV, 5) ->LvlNutrient(?mn, LowCarbo)

RESULT

The system provides menu recommendations based on user input. The development process involves utilizing the Python programming language. For database management, sqlite3 is employed. Subsequently, integration with Telegram is established through the provided Telegram API. The system's input encompasses user particulars like name, gender, age, physical activity level, height, and weight. Food suggestions, complete with nutritional details and recommended consumption times, are provided. The interaction procedure with users is illustrated in Figure 6.
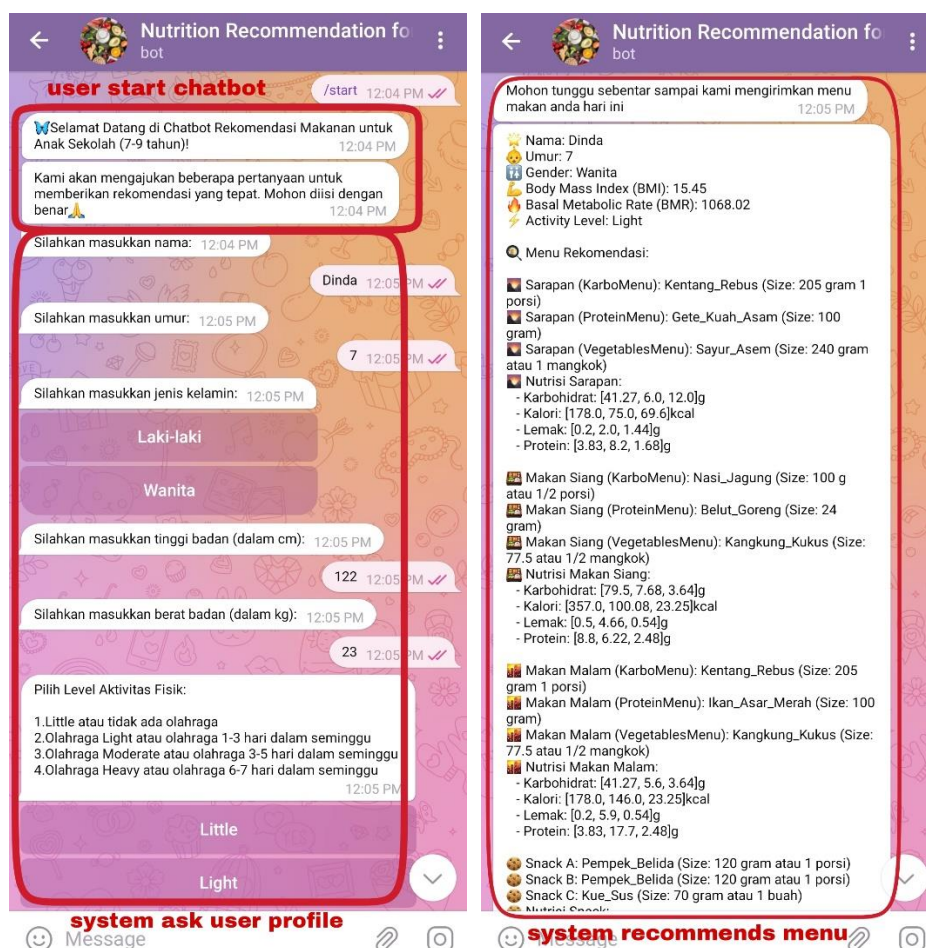

Fig 6. Interaction between user and NutritionChildrenBot on Telegram

After the user inputs the required information, food menu recommendations will be provided via the chatbot platform. The information that will be presented includes user data, Body Mass Index (BMI), and Basal Metabolic Rate (BMR). After that, it displays the various meal options presented to the user, including meal plans for breakfast, lunch, dinner, morning snack, and evening snack. These recommendations align with the user's calculated Body Mass Index (BMI) and Basal Metabolic Rate (BMR), as calculated by the system.

The process of testing food selection recommendations involves nutritionists validating the results of the recommender system we have built. User data samples for the validation process were obtained from pediatric patient data with an age limit of 7-9 years at TK Bhayangkara II Sartika Asih Hospital, Bandung. The number of data samples to be used is 20 samples consisting of name, age, gender, height, weight, and physical activity. The collected sample patient data will undergo processing within the chatbot system, resulting in the generation of tailored food menu recommendations. The meal

suggestions comprise breakfast, lunch, dinner, and two snacks. This procedure leads to the generation of a total of 100 sample meal recommendations. Out of the 96 instances of dietary recommendations endorsed by multiple nutritionists, there were four that did not receive approval from the nutritionists.

$$Precision \ = \ \frac{TP}{TP + FP} = \frac{96}{96 + 4} = \ 0.96 \qquad (1)$$

$$Recall \ = \ \frac{TP}{TP + FN} = \frac{96}{96 + 0} = \ 1 \qquad (2)$$

$$F\_Score \ = \ 2 \ \times \frac{Precision \times Recall}{Precision + Recall} = \ 2 \ \times \frac{0.96 \times 1}{0.96 + 1} = \ 97.9\% \qquad (3)$$

Utilizing this value, the precision, recall, and F-Score calculations yielded a result accuracy of 98.1% for the system's recommendations.

DISCUSSIONS
In this research, we develop an ontology and create SWRL rules for use with the ontology. We build Telegram Chatbot using Python Language. The chatbot that we created will interact with users via Telegram. Users will be asked to fill in some information so that food menu recommendations are given according to their body needs. The expert validation process is very useful in determining the effectiveness of this system from the ontology, SWRL rules, and chatbot implementation. This research results in the creation of a knowledge-based system with strong validation. The limitation of this research is server limitations. In addition, this system does not endure long-term allergies.

CONCLUSION
NutritionChildrenBot is a chatbot that recommends food menus and mineral water intake for school-age children without complications. Following the conducted validation, the outcomes indicate an accuracy rate of 97.9% for this chatbot. Consequently, the chatbot proves adept at furnishing food and mineral water suggestions aligned with the user's nutritional requirements. It emerges as a viable solution for aiding users in cultivating healthy dietary and hydration practices among school-aged children.

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*name of corresponding author