

# An Architecture of Web-based Application for Thyroid Disease Identifying

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**Abstract.** To identify the problems with thyroid gland, an algorithm based on blood test results is developed. This algorithm is implemented in a web based application with client-server architecture. Three-tier architecture is used to realize the user interface, business logic and computer data storage and data access. Using the document object model of the HTML and JavaScript make it is possible to create user interaction with the application. Interaction between JavaScript, HTML and CSS allows loading pages faster. The described web application to identify the thyroid disease has been tested in different browsers and on different operating systems and showed no errors in its work. The developed web application can be used as a standalone application or be incorporated into other specialized Internet resources in the subject area.

**Keywords:** AJAX technology, Three-tier architecture, Thyroid disease, Web application.

**Citation:** D. Borissova, E. Tabakova, V. Grigorova. An Architecture of Web-based Application for Thyroid Disease Identifying. *Trends Journal of Sciences Research*. Vol. 2, No. 1, 2015, pp. 46-49.

## Introduction

The main role of thyroid in the endocrine system is to regulate metabolism which provides a breakdown of food and convert it into energy. The thyroid gland is among the most significant organs of the endocrine system. The thyroid gland synthesizes and secretes T3 and T4 hormones and these hormones play an important role in the functioning of the body. Thyroid disorders typically occur when this gland releases too many or too few hormones. Symptoms of thyroid disease include weight loss or gain, hot flashes, fatigue, constipation, dry skin, and more. The problems of thyroid diseases can be defined as abnormal enlargement of the thyroid gland (goiter), hypothyroidism (when thyroid does not make enough thyroid hormones), hyperthyroidism (when thyroid makes more thyroid hormones than the body needs), Hashimoto's thyroiditis and thyroid cancer. A simple goiter can occur without a known reason. It can occur when the thyroid gland is not able to make enough thyroid hormone to meet the body's needs.

Blood testing is now commonly available to determine the adequacy of the levels of thyroid hormones. These blood tests can define whether the thyroid gland's hormone production is normal, overactive, or underactive. This is why the proposed web-based application concerns the identification of the problems with for thyroid diseases if they exist.

Hyperthyroidism or overactive thyroid is a condition in which thyroid gland produces too much of the hormone T4 and/or T3 is produced. Proper diagnosis and treatment of the underlying cause relieves symptoms and prevents complications. Hyperthyroidism can run in families. A

variety of conditions can cause hyperthyroidism. Graves' disease (an autoimmune disorder) is the most common. It occurs more often in women and tends to run in families. In Graves' disease, antibodies stimulate the thyroid to secrete too much hormone<sup>1</sup>. Hyperthyroidism can accelerate your body's metabolism significantly, causing sudden weight loss, a rapid or irregular heartbeat, sweating, and nervousness or irritability.

Hypothyroidism is defined as failure of the thyroid gland to produce sufficient thyroid hormone to meet the metabolic demands of the body [1]. Hypothyroidism may occur as a result of primary gland failure or insufficient thyroid gland stimulation by the hypothalamus or pituitary gland. Primary gland failure can result from congenital abnormalities, autoimmune destruction (Hashimoto disease), iodine deficiency, and infiltrative diseases. In case of hypothyroidism the quantity of thyroid hormone is less than normally in the blood. This condition is characterized by delay of all the processes of metabolism in the body. The patients are feeling tired, weak, unwilling to move, the mood is depressed, the hair becomes brittle and begins to fall, the voice becomes deeper and raspy and the body retain water. The best laboratory assessment of thyroid function, and the preferred test for diagnosing primary hypothyroidism, is a serum TSH test [2]. If the serum TSH level is elevated, testing should be repeated with a serum free thyroxine (T<sub>4</sub>) measurement [3]. Hashimoto's thyroiditis is the most common cause of

<sup>1</sup> <http://www.healthline.com/health/hyperthyroidism#Overview1>

hypothyroidism (having too low levels of thyroid hormones) Hashimoto's thyroiditis is a condition caused by inflammation of the thyroid gland. It is an autoimmune disease, which means that the body inappropriately attacks the thyroid gland – as if it was foreign tissue. There exists so called congenital hypothyroidism [4]. Congenital hypothyroidism is inadequate thyroid hormone production in newborn infants. It can occur because of an anatomic defect in the gland, an inborn error of thyroid metabolism, or iodine deficiency. For its identification and treatment all newborn is tested for the level of TSH.

The thyroiditis can be categorized by the following inflammatory diseases of the thyroid gland: (1) acute suppurative thyroiditis, which is due to bacterial infection; (2) subacute thyroiditis, which results from a viral infection of the gland; and (3) chronic thyroiditis, which is usually autoimmune in nature. Acute suppurative thyroiditis resulting from a bacterial infection is an infrequent but potentially life-threatening endocrine emergency [5]. Subacute thyroiditis is a form of thyroiditis that can be a cause of both thyrotoxicosis and hypothyroidism. In general, the following 3 forms of subacute thyroiditis are recognized: 1) Subacute granulomatous thyroiditis – also known as subacute painful or de Quervain thyroiditis; 2) Subacute lymphocytic thyroiditis also known as subacute painless thyroiditis; 3) Subacute postpartum thyroiditis. Chronic thyroiditis or Hashimoto disease is a common thyroid gland disorder. It can occur at any age, but is most often seen in middle-aged women. It is caused by a reaction of the immune system against the thyroid gland.

Thyroid cancer is an uncommon type of cancer that affects the thyroid gland [6]. There are four main types of thyroid cancer 1) papillary carcinoma – this is the most common type that affects people under 40 years of age, particularly women; 2) follicular carcinoma – tends to affect older adults; 3) medullary thyroid carcinoma – unlike the other types of thyroid cancer, medullary thyroid carcinoma can run in families; 4) anaplastic thyroid carcinoma – is the rarest and most aggressive type of thyroid cancer that affect older people aged 60-80 years.

## Algorithm to Identify Thyroid Problems

Thyroid disease is usually diagnosed through blood tests that examine the levels of thyroid hormones in the blood. Another method for diagnosis of thyroid problem is based on ultrasound and allows detecting the changes in structure of thyroid and indicates the existence of some problem.

To identifying the problems with the thyroid gland an algorithm for detecting the diseases based on the results of blood tests is proposed. This algorithm is illustrated in Figure 1.

The algorithm starts with a sequential study of thyroid hormones FT3, FT4 and TSH by a blood test. The results are classified as normal, smaller or larger values of the corresponding hormone. Depending on the values obtained from different thyroid hormones it is possible be classified the condition corresponding hypofunction, exogenous hypofunction, hyperfunction and identification

of the disease. Following the steps of this algorithm it is possible to determine the existence of problems with the thyroid gland.

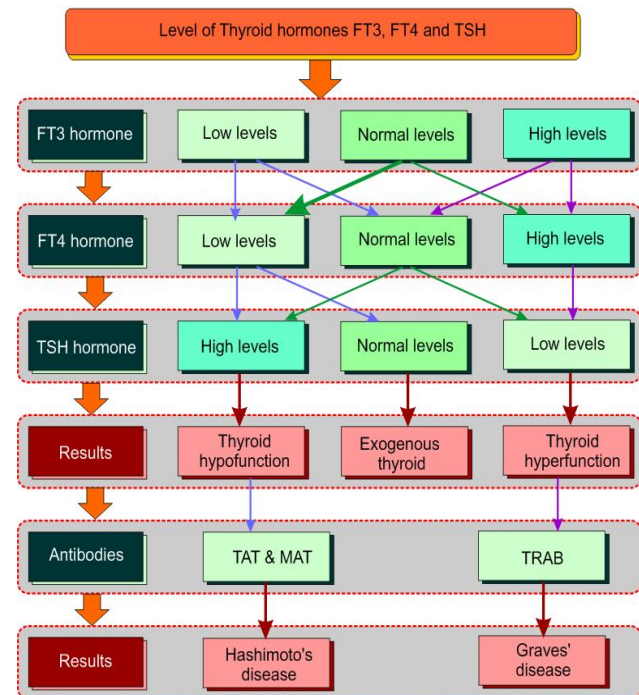


Figure 1. Algorithm for identifying the problems with the thyroid gland based on blood tests Normal.dotm

## Architecture and Algorithm of Web Application for Identifying Thyroid Disease

The key element of any application design is the system architecture. The system architecture defines how modules of the application interact with each other and define the functionality each module.

Traditionally, web application has two-layer and is known as client/server architecture and logic is divided between these two physical locations. Three-layer architecture uses layers that describe the separation the functionality and that can be located on a physically separate computer. The developed prototype of a web application to identify thyroid problems can be illustrated by the generalized three-layered architecture as shown in Figure 2.

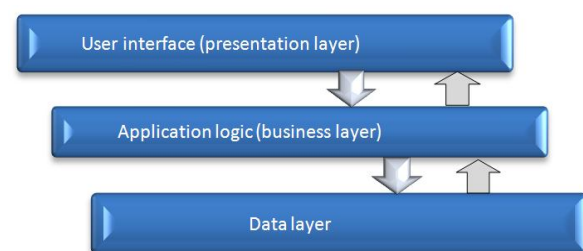


Figure 2. Three-layer architecture

The three-tier architecture is also client-server architecture there the user interface (presentation layer), functional process logic (business logic layer), computer data storage and data access (data layer) are developed and maintained as independent modules and often on separate platforms. In a three-tier design, the user interface runs on the client and the data is stored on the server, just as with a two-tier design [7]. A three-tier design also has a middle layer between the client and server that processes the client request and translates them into data access commands that can be understood and carried out by the server.

Client layer is responsible for presenting information to the user and ensures different requests to the system. This layer can be represented as the user interface providing the access to the application in the browser environment. Another function of this layer is to provide the interaction between the user and sending requests to the data layer through logic layer.

Application layer is the intermediate layer between the user interface and the data layer. It provides management of data exchange, realizing application logic serving the user (business logic). Data layer communicates with the business logic and serve to store data and their accessing. In database layer the information is stored independent of the business logic or application server. When data is stored in a separate layer increased scalability and improved performance.

The described architecture is based on AJAX technology (Asynchronous JavaScript and XML). AJAX is one of the most popular rich Internet application technologies [8]. The main idea behind the architecture of the AJAX engine is the reuse every time is needed some asynchronous processing or a smart way to refresh information on the current web page without reloading it [9]. Using the AJAX technology enables web applications to call the web server without leaving the actual page and in the background without notice of the user (through XMLHttpRequest). This avoids loading the same form or

page including the html code multiple times, reduces the network traffic and increases the user acceptance.

The described architecture based on AJAX technology is illustrated on Figure 3.

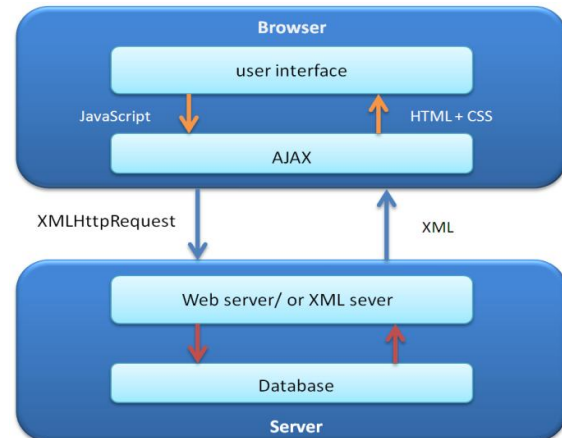


Figure 3. Three-tier architecture based on AJAX technology

In practice, AJAX engine is realized as JavaScript functions that are called whenever information needs to be requested from the server. When the AJAX engine receives the server response, it goes into action, often parsing the data and making updates of the presented to the user information. Because this process involves transferring less information than the traditional web application model, user information updates are faster. The advantage of client-side is the independence from the server-side technology.

The implementation of web application is based on the described architecture in Figure 3 and proposed algorithm in Figure 1. The developed graphical user interface (GUI) of the proposed approach for identifying thyroid diseases is shown on Figure 4.

FT3 hormone	FT4 hormone	TSH hormone
reference range	reference range	reference range
Low levels <input type="radio"/>	Low levels <input type="radio"/>	Low levels <input type="radio"/>
Normal levels <input type="radio"/>	Normal levels <input type="radio"/>	Normal levels <input type="radio"/>
High levels <input type="radio"/>	High levels <input type="radio"/>	High levels <input type="radio"/>
Result		
Antibodies	TAT & MAT <input type="checkbox"/>	TRAB <input type="checkbox"/>
Result		

Show Description

Figure 4. GUI of thyroid diseases manager prototype

Thyroid function tests provide information about hormone metabolism and thyroid dysfunction. Lab reports tend to provide only the high and low limits of normal values. The laboratory techniques for tests vary and lab values may have a 5-10% margin of error depending on the laboratory used. The reference ranges of these hormones can be visualized by activating the corresponding buttons for each hormone (Figure 4). The business logic behind the GUI can be illustrated by the following proposed algorithm (Figure 5)

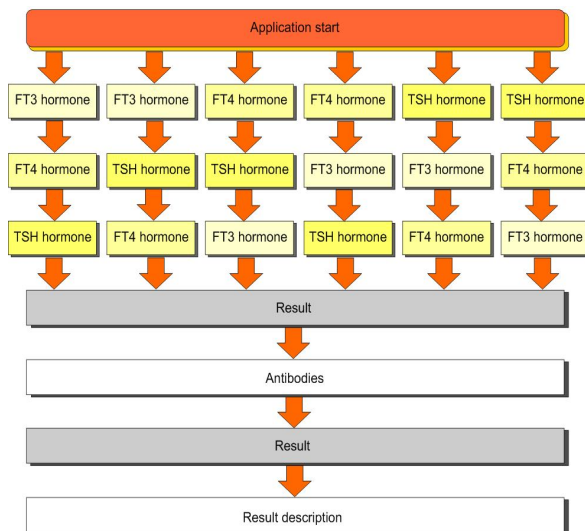


Figure 5. Algorithm for web application performance

For example, if hormone T3 is relatively lower than T4, it means the body is jamming on the metabolic brakes. This can be seen in early Hashimoto's Thyroiditis where the T4 hormone is high (because of spillage from a damaged thyroid into the blood stream). Hyperthyroidism is an example of Graves Disease and is the clinical syndrome caused by an excess of circulating free thyroxine (FT4), free triiodothyronine (FT3) or both of them.

Depending on the values of thyroid hormones FT3, FT4 and TSH obtained via blood test, the proposed web application can determine the related thyroid diseases if exist. Following the steps of this algorithm it is possible to determine the existence of problems with the thyroid gland.

The levels of hormones can be checked in any sequence due the business logic behind the application follows the proposed algorithm shown on Figure 1.

## Discussion and Conclusion

The thyroid diseases are typically diagnosed through blood tests that examine the levels of thyroid hormones in the blood. Therefore, to identify problems with the thyroid gland, an algorithm for detecting of the disease based on blood test results is offered. A proper client-server architecture is proposed for web based application that implement the proposed algorithm for indentifying the thyroid diseases.

Three-tier architecture is used to realize the user interface, business logic and computer data storage and data access. For the realization of web application the programming languages HTML, CSS and JavaScript and jQuery are used. The usage of document object model and JavaScript make it is possible to create user interaction with the application. JQuery is responsible for the interaction between JavaScript, HTML and CSS and allows loading pages faster.

The graphical user interface is implemented by the means of HTML. Document object model and JavaScript allows the user to interact with any element of and can even manipulate the item. The described web application to identify the thyroid disease is tested in different browsers and on different operating systems and showed no errors in its work. Thus developed web application can be used as a standalone application or be incorporated into other specialized Internet resources in the subject area.

The experimental results demonstrated that the implementation of the proposed algorithm is quite helpful and facilitate the process of detection of thyroid gland problems. The testing of developed prototype showed the practical applicability of the described application. The simple and intuitive GUI was very well accepted by the students and practitioners.

As future development it is intended to incorporate a module for an analysis of the size of the thyroid gland as a result of ultrasound tests to determine the extent of improvement or worsening of the thyroid functions.

## Acknowledgment

The research work reported in the paper is supported by the research project "Innovative optimization methods for decision-making".

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