Abstract — Web alerts are user-defined monitor conditions for public Internet information in which notification messages are sent to users whenever their alert conditions are met. The notification conditions are directly or indirectly and completely or partially based on public information available on the Internet such as news, stock prices, exchange rates, oil price, etc. In some alert services, the user can reuse this information to define alert conditions for some required interests in which mobile phone text messages, instant messages, or email alert messages are sent to them upon meeting the pre-specified alert conditions. This paper discusses currently available alert models and some research based proposed models. Then it provides a classification of these different web alert models. This study also provides engineers and researchers with an overview of these models and their types then discusses several system design issues and challenges related to each alert model.

Keywords: Web alerts, Web Information, Internet, Notification Systems.

1. INTRODUCTION

Recently, the Internet users rely heavily on the Internet to get up-to-date information about recent news, stock markets information, weather forecasts, movies and entertainment information, etc. There are three main approaches to get this information. The first is browsing and it started with the beginnings of the concept of the Internet. A user can navigate from one web page to another to obtain the required information. The second approach is searching, where a user provides keywords to be searched for in the available documents. The third approach is the notification or alert, where a user defines some notification criteria for specific events on some websites. The user is notified whenever his/her criteria are met. The notification can be delivered by SMS, instant messages, or email messages. Alert services are personalized notification services that instantly inform you of changes in the predefined areas of your interest.

Generally, a notification system is a combination of network services and an infrastructure that provides a mechanism of delivering notification messages to a single or multiple recipients based on the occurrence of an event specified by the recipients. Notification systems usually consist of two players, the publisher/producer and the subscriber/consumer. There are different notification systems used for different domains and applications such as telemedicine applications [1], accrual failure detectors [2], e-commerce applications [3], emergency services [4], and finance/banking.

On the web, there are a number of alert services available for notifying about public information of interest to the users. Web notifications are messages sent to a user based on his/her defined monitor conditions. These conditions are directly or indirectly and completely or partially based on public information available over the Internet such as stock prices, exchange rates, oil price, etc. The user can reuse this information to define notifications for some required interests in which SMS, instant, or email notification messages will be sent to them upon meeting the pre-specified notification conditions. This paper provides classifications of different web notification models. This study provides engineers and researchers with a comprehensive classification and system design issues related to each alert type. In addition, challenges and system requirements for implementing and supporting each type are discussed.

In the rest of the paper, Section 2 covers some related work. The applications of web alerts are discussed in Section 3. Section 4 classifies different web alerts and discusses their advantages and disadvantages while Section 5 provides a discussion of their design and implementation issues and challenges. Section 6 concludes the paper.

2. RELATED WORK

Several publications are available on notification systems representing different projects, protocols, and architectures. Huang et al. [5] provide a comparative study of web services (WS) based event notification systems. The authors focus on the evolution of major specifications of notification systems. Several organizations proposed various event notification systems such as CORBA notification service specification [6], the notification specification in Open Grid Services Infrastructure (OGSI) [7], Web Services Eventing (WS-Eventing) [8], and Web Services Notification [9][10][11][12]. Carzaniga et al. [13] present SIENA (Scalable Internet Event Notification Architecture), which is an Internet-scale event notification middleware service for distributed event-based applications deployed over wide-area networks. Additionally, the authors in [14] discuss and classify the various models of the publish/subscribe communication paradigm. It presents the common denominator underlying these models with respect to time, space and synchronization. It also identifies the benefits and shortcomings of the various systems in terms of interfaces and implementations. In these
notification systems, both the publishers and subscribers must follow specific communication protocols to enable the notification process. In some projects, the intermediate network among publishers and subscribers also must provide some support to enable the notification process.

In this paper we concentrate in studying, classifying, and discussing some current and proposed web alert services for monitoring live Internet-based information.

3. WEB ALERT APPLICATIONS

There are several alert services available over the Web, which serve different application domains. One example of these domains is entertainment. The users can subscribe to get updates on new computer games and computer game sale promotions, new and recommended movies, sports, and special events. The user can specify the type of sports or event information he/she interested in and alert messages will be sent to him/her.

Another domain is the news. The users can subscribe to get information about breaking news, and daily based on their specified types they have interest in. These types could be business, top stories, science, weather, world, politics, or technology. In addition, some services are available to provide keyword-based news. The users can request to receive news that contains specific keywords. For example, a user may be interested in news about a specific company. Therefore, he/she can use the company’s name as a keyword in the alert definition. Users may also need to specify their locations for some interests and news alert types. For example, when requesting local news alerts or missing children alerts.

Another applications domain is finance. Stock investors can subscribe to get information about stocks, currency exchange rates, and market summaries. For example, a stock investor can set an alert condition on Yahoo Finance such that whenever the Wal-Mart stock price drops to a specific value in US dollars a notification is sent. Another application domain is related to our daily life with weather and traffic. The user can get weather forecasts sent to him/her for certain cities he/she specified. In addition, the user can specify to get alerts about snowfall in certain cities. For traffic alerts, the user can subscribe to get alerts when traffic jams occur on specific highways he/she uses. Another alert application is for job openings. The user can specify some keywords for available jobs. The user must in this case also specify the location and job category in which he/she will receive alerts about.

Although, there are some alert services for stocks information, these services are very restricted. The user is restricted to specific types of information and limited types of notifications. Users have no means of defining advanced criteria he/she may be interested in. In addition, the data used for notification is usually limited to what is available on the website of the company managing the notification system. For example, an investor can set a notification condition in Yahoo Finance such that whenever the Wal-Mart stock price drops to a specific value in US dollars a notification is sent. However, the investor cannot define advanced notification criteria such as “when the trading volume reaches a specific quantity and when the Wal-Mart stock price reaches to a specific price in Euros;” although, both the trading volume and the USD to Euro exchange rates are available over the Internet. Hence as Yahoo Finance does not support that type of notification, an investor cannot define these advanced criteria.

4. WEB ALERTS CLASSIFICATION

As we mentioned in the previous section, there are a number of alert services available for public live information over the Internet. In addition, there are a number of advanced alert services that may be available in the near future. In this section, we classify these services and discusses their advantages and disadvantages.

A. Pre-Defined Alerts

In this type of alerts, alert fields, information, and conditions are restricted. The users have a limited set of fields, information, and conditions that they can use to define their alert interests. This type of alerts is simple and can be easily used by regular users; however, they will not be able to define advanced or complex alert conditions. In addition, the information used for such alerts are limited to those owned or managed by the service provider only. Therefore, updates and changes in other websites or companies may not be included. One example of this type of alerts is Yahoo Stocks Watch Alert [15]. The Yahoo Stocks Watch Alert provides users with some options to set their notifications for stocks information. These options are based on changes in stock prices either in value or percentages. For example, the user can receive a notification whenever the Wal-Mart stock price increases above $50.00 or when the price drops below $44.00. In addition, the user can define to receive notification messages whenever the price increases or drops by a certain percentage. Figure 1 shows the Yahoo Stock Alert setup screen, the user can receive notifications as an email message, an instant message or as text message over the mobile phone.

![Figure 1. Yahoo Stock Alert Setup Page.](image)

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B. Search-Based Alerts

This can be also called keyword alerts. One of the services available based on keywords search is Google Alerts [16]. The user defines keywords for a topic of
interest and email alerts will be sent to him/her whenever any article is published over the Internet about that topic (see Figure 2). This service can be used to get up-to-date information about specific interests. The search can be for news, blogs, web pages, videos, or interest groups. This type of service is similar to using an Internet search engine for finding articles that contain some keywords defined by the user. However, the search will be done offline on any future articles becoming available within a specified amount of time and alerts will be sent when any match is found. This type of service allows users to follow specific trails of information about their interests without having to repeat the search manually several times. In addition, this will provide continuous updates without having to filter through duplicate search results every time a manual search is started.

Figure 2. Google Alerts

C. Webpage Change Alerts

This type of alert services is available to monitor changes in specific web pages. One example is ChangeDetect [17]. ChangeDetect is a service that monitors a specified web page contents for changes and sends an automatic alert email to the user whenever the web page is updated. A user can use that service to be notified of new posts on interesting sites. For example, a user can monitor news on a company’s website to know of any upcoming events or news posted on that company’s website. In addition, a user can use that service to monitor a job openings site such that an alert is sent to him/her as soon as the page changes (which in this case means some new job openings were posted or current ones are updated).

D. Value-Based Alerts

This type of alerts is still in the research stage, but shows potential of becoming very popular. It allows users to define alerts based on any values publicly available over the Internet through web services or dynamic HTML documents and build notification conditions using these values. For example the user can define criteria to monitor the volume value of ALDAR Properties that is shown on the ADX website (see Figure 3). The user can define to get an alert whenever that number reaches a certain value. More information about this service is available in [18][19]. This alert type started to get industry attention in some of their new products [20].

Figure 3. ALDAR Stock from Abu Dhabi Securities Exchange Website.

In this type of service, the user defines the required value by defining a fixed text that appears before the required value. Recently an efficient approach for retrieving live HTML-based Internet information was developed [21]. This approach can be used to define the alert variables that will have their data updated from the Internet. The main idea of this approach is based on finding fixed titles or headers that appear in the browser for HTML documents directly or semi-directly before the needed dynamic information. These fixed titles or headers are used as references to know the position of the required dynamic information. This is necessary since we are not dealing with a single information provider that could have internal representations of the values and access them directly. This approach uses any available information on the web and the only way this information is accessed is as HTML text. As a result, it is not possible to identify changing variables within the page directly. Therefore, it is accessed based on the overall format of the page and the fixed titles used. The proposed approach is developed as a Java class. Multiple objects can be created form this class for different Internet HTML documents that contain some of the required information. A number of techniques were developed to find this information in any HTML document. These techniques are implemented in a set of methods. More information about the implementation and performance of the mentioned approach can be found in [21].

If the information needed by alert services is available by web services, then users can use the corresponding web services which provide the required information. The main problem with web services is that not all types of information available over the Internet are provided by web services.

E. Calculated Values Alerts

This type of alert is similar to the Value-Based Alert mentioned in subsection 4.D. However, the alert information can be obtained from multiple web pages and/or multiple web services. In addition, the values of new variables can be calculated from the defined values obtained from the Internet. In this type of service the user defines two types of variables: Internet variables and
calculated variables. The values of Internet variables are obtained directly from the Internet in a similar way as described in subsection 4.D. The values of the calculated variables are generated by combining the defined Internet variables and other defined values based on some formula defined by the user. The user can use both the Internet variables and calculated variables to define the alert conditions.

To illustrate the concept of this alert type, we will consider an example of an investor (using the Euro as a trading currency) who would like to know when the EMAAR stock listed in Dubai Financial Market (DFM) in Dirham if the price increases above 2 Euros. Two types of information are needed here, the stock price in Dirham offered by the market website as shown in Figure 4 and the Dirham to Euro exchange rate which is offered on a different website as shown in Figure 5. Both values are dynamic and finding the correct price normally requires the investor to open the web pages for both sites and continuously perform currency conversions on the listed price until the desired value is reached. However, using the alert service the investor will automate the process and will only need to wait to get the message when the criteria are met. To do that the investor needs to define two variables for the current stock price in Dirham, EmaarAED, and the current exchange rate between Dirham and Euro, AEDEUR.

The user then uses these two Internet variables to derive a calculated variable, EmaarEUR, for the current stock price in Euro (EmaarEUR = EmaarAED * AEDEUR). After that, the investor must specify the condition at which an alert message will be sent to him/her as soon as the price reaches the desired value in Euros (send alert when EmaarEUR > 2 Euros).

This type of alert service provides some flexibility for users to define advanced alerts. This is very important for stock investors [22] for example. Stock investors rely on live up-to-date information to make informed decisions on their investments. The Internet hosts numerous sources of such information that anyone can access and use for their benefit. However, this information is scattered and distributed across hundreds, if not thousands, of sites and most of it is updated very frequently. In addition, the events and changes in investment-related fields occur frequently and in non-deterministic patterns. Therefore, the investor’s ability to follow and analyze this information becomes limited and he/she is forced to ignore many pieces of essential information when making on-the-spot decisions. For example, if an investor is managing a stocks portfolio containing stocks from multiple companies in various countries, it is essential to follow all events and changes occurring for any and all of them before making decisions to buy or sell any of these stocks or rebalance the portfolio. Having to go through company financial records, stock prices, volumes being sold, demand values, currency exchange rates, etc. requires long hours of monitoring and analysis. However, investors usually do not enjoy the luxury of time. In an ideal situation, decisions must be made within minutes of perceived events. This type of alert service discussed in this section can provide a tool that helps stock investors in taking such fast decisions.

F. Temporal Alerts

In this alert type, time is part of the defined alert conditions. That is to satisfy an alert condition of this type, the service must keep track of some values and their changes over some period of time. These alerts require the user to identify some internet variables as in subsections 4.D or 4.E then also specify the change factors and the amount of time required for that change. One example of this alert type is an alert that should be sent when the Microsoft stock price drops by $4 within one hour. In this case the service needs to keep track of all changes of the Microsoft stock price over time and compare the values until the difference of $4 is perceived within one hour. Another example is when alert should be sent when the temperature in Lincoln, Nebraska increases by 10% within 24 hours. This type of alert requires special system requirements discussed in the next section.

G. Group Alerts

Related Internet information can be scattered over multiple web pages or available on a single web page. It can be provided by multiple web services or can be provided by a single web service. Example of this type of information is all stock information listed in NASDAQ market in USA. Another example is current temperatures of
all cities in Germany. A user can define a group alert such that he/she will be notified when the price of any stock listed in NASDAQ increases by 30% from the opening price. This alert type deals with multiple related pieces of stock information that could be scattered over multiple web pages or web services on the Internet. In this case the service does not have one or a few defined variables to monitor. Instead, it will need to keep track of all values available that are relevant to what the user defined. Once more, there are specific requirements for this type of alerts that we’ll discuss in the next section.

H. Other Types

Other types of alerts can be combinations of the types discussed above. In this case more complex methods may be needed to provide the user with the right tools to define the alerts conditions. For example a user wants to know whenever any stock listed in NASDAQ drops by 20% within one hour. This type of alert is both temporal and group alert. This type requires the user to define the monitored pages (e.g. NASDAC stocks) in addition to the timing conditions for the monitor.

5. Web Alerts Implementation Challenges

Pre-defined, search-based, and webpage change alerts are already implemented and used over the Internet by companies such as Google and Yahoo. The pre-defined alerts can easily be implemented since they restrict users with specific information and condition types. Restricted information and conditions also allow alert service to be easily optimized. For example, if a user wants to be notified when the Wal-Mart price drops to $42, and another user wants to be notified when the price drops to $41, while a third user wants to be notified when the price drops to $40. These notifications conditions can be sorted based on the required price and whenever the price reaches $40 the required alert messages will be sent to all three of them.

The search-based alert services can also be easily implemented by having processes periodically search the Internet based on the defined keywords and send alerts when new articles are found. This service type needs to maintain a record of information about old articles to ensure that alerts are sent for new postings only. For companies that already provide Internet search engine services, they already maintain information about new articles found that need to be included to their search indexes. Therefore, they can conduct the search only in the new articles and send the alerts to the interested users when their keywords are matched. In this case, there is no need to maintain information about old articles that were previously matched with the user requests.

The web page change alerts can similarly be easily implemented by having processes periodically check monitored web pages and compare them with the old pages. Instead of storing the whole pages hash techniques can be used to minimize the amount of required stored information and the processing time for comparisons. For all these three types parallel processing can be used to reduce processing time and speedup response time. This is mainly because these types of tasks are easily dividable and their operations can be performed in parallel.

The value-based, calculated values, temporal, and group alerts are new services and still under research. These types can provide advanced and flexible alerts services; however, there are a number of research issues that need to be considered for their effective implementation and processing [18].

These alert services can be implemented as a single user system as discussed in [19] or as a multi-user web server. For the multi-user server, the main issue is how to optimize the server operations to avoid any repetitive operations due to similar or semi-similar user-defined notifications. In addition, if we have a web server that provides these alert services for a large number of users; how these services can be best implemented and optimized on a cluster of computers to enhance the performance.

Another important issue is that some Internet information can be very dynamic. Example is the current price of a stock, where the values change very frequently (e.g. every second). The issue here is how an alert service can efficiently capture all value changes. In addition, Most HTML documents have a relatively fixed structure and are mostly updated within the original format. However, a problem may occur in some cases when the component formats of the HTML document are changed. By this we mean adding extra fields with the same labels we used. An automatic validation mechanism is needed to allow the system to make sure that the formats of the defined HTML documents were not changed before attempting to extract the information for the Internet variables. One possible solution for this problem is to automatically capture and store the format patterns of the HTML documents. These patterns can be used by the system to discover any future changes in the downloaded documents. In case there are some changes, the system notifies the system administrator to configure the new parameters for the Internet variables. This issue is not available with using web services to retrieve the required information. However, the main problem is that most information is still available in dynamic HTML over the Internet.

Regular users should be able to use the alert services. The issue here is in how to provide a basic graphical interface to allow regular users to easily use and define Internet and calculated variables. Initial work in that field is available in [23].

Supporting pre-defined Internet variables can solve some of the above issues. Pre-defined Internet variables are a set of variables that are used frequently by users for different notifications. Instead of defining them multiple times, a system can provide them and users can use them directly. The issue here in how these variables are identified and efficiently offered in alert systems.

Both temporal and group alerts are considered advanced and more complex to be supported. Implementing temporal alerts can be more difficult than other types since it requires not only processing of the current available information but it also requires to store previous information as they are needed for alert condition processing. Due to this additional
task, the temporal alert is more complex than other types. Here the issue is how to minimize the required information to be stored for temporal alerts. With group alerts, more online information is needed to be available for processing. The issue here is how group notification conditions can be defined and efficiently supported.

6. CONCLUSION

There are a number of alert services available over the Internet. As we studied and classified them we could address them as two major categories. The first includes simple alert systems such as the pre-defined, search-based and webpage change alerts. In addition, there are other advanced services being proposed such as value-based, calculated values, temporal and group alerts. These services provide flexible alert services for users to implement their personalized alerts and notifications. However, these types also raise several design and implementation issues that need to be effectively addressed and resolved. Some of the issues involve optimizing performance, efficiently supporting multiple users, and optimizing storage requirements among others.

ACKNOWLEDGEMENTS

This work was partially supported by a UAE University research grants #01-04-9-11/09 and #01-03-9-11/08.

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