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Notifying Investors in Time - A Mobile Information System Approach

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ABSTRACT

Within the non-institutional investment sector, private investors are usually not able to monitor all new public available information which might have significant impact on their portfolio value. This scenario might be a promising domain for mobile push information services. In order to prove these potential capabilities, this paper examines short term security price reactions following new information available to the capital market. After identifying determinants of the observed price effects and effect delays, a suitable mobile push infrastructure is introduced, which can provide an investor notification in time. It is shown how personalized combined mobile push/pull services can provide a reasonable proportion of sending portfolio relevant information immediately and reducing the level of user-intrusiveness to a manageable dimension.

Keywords

Mobile Information Systems, Mobile Brokerage, eFinance, Push/Pull Services, Service Indication

INTRODUCTION

So far, most existing financial information systems supporting private investors in making their investment decisions are limited to web-based pull services. Available mobile information services are mostly reproductions of theses web-based information systems and provide only little personalized information supply. Even the combination of personalization and the contemporary information delivery, which could be realized by appropriate mobile push services can add value to the investors, e.g. when potential losses can be prevented because the investor can react to portfolio relevant market events in time.

This paper demonstrates the potential of such personalized mobile financial information systems. This is done by analyzing short time (intraday) security price reactions caused by new information available to the capital market. The analysis bases on observed ad hoc disclosures published by publicly listed German companies as the event to focus on.

Most of the event studies conducted so far use daily stock returns and concentrate on interday-behaviour (Brown and Warner, 1984). Because of this long-term focus these studies are inappropriate for exposing the adding value which can be realized by mobile financial information services. Nevertheless, there are a few studies which concentrate on intraday price effects. Patell and Wolfson (Patell and Wolfson, 1984) examine the intraday speed of stock price reactions to earnings and dividend announcements. They show that most of the detected price reactions occur within the first fifteen minutes after the announcement has been published. Woodruff and Senchak (Woodruff and Senchak, 1988) analyze intraday price reactions caused by unexpected earnings results. They find prompt price reactions persisting up to one hour. Barcley and Litzenberger (Barclay and Litzenberger, 1988) analyze price reactions occurring after announcements of new equity issues also on an intraday basis. They observe an abnormally high trading volume and a negative average return for fifteen minutes following the publication.

The existing literature published until today only provides an analysis of these price effects but does not consider requirements of adequate information and decision support systems. Furthermore, the used datasets of these event studies do not imply the changed reaction time of investors caused by the emergence of powerful web-based financial information systems available to non-institutional investors in recent years.

The observed intraday price reactions can disclose the capability of adequate mobile push information systems if statistical significance can be detected. Furthermore, an analysis regarding the intraday speed of stock price adjustments can give valuable information concerning remaining reaction time for the investors. Assuming an efficient capital market, the new information should be priced into stock market rates very quickly. After analyzing this capital market behavior, I propose possible determinants (e.g. trading volume of the previous day or the market capitalization of the company which has published the ad hoc disclosure) of the reaction magnitude (price effect) and the stock price adjustment speed (effect delay). Performing a multiple stepwise regression it is possible to identify the influencing variables of the observed price effects, which are the critical success factors when designing an intelligent and personalized mobile information and decision support system. Being able to predict the relevance of an announcement regarding price reaction magnitude and delay, the priority of a notification sent to a mobile device can be evaluated. Furthermore, this forecast allows to identify irrelevant announcements, which can help to reduce the level of user-intrusiveness to a manageable dimension.

I propose a notification infrastructure, in which the relevance estimation of new published company announcements is made server-side involving the current investors' portfolio status. This estimation valuates whether an expected price effect is significant or negligible. Only if significant, the investor will be informed via a mobile push service. Furthermore the estimation of the price effect delay can be used to determine the message priority and expiration timestamp. In consequence I propose the usage of the Service Indication (SI) content type, which enables meta information processing such as the expiration date of a push message (WAP Forum, 2001a). It can be shown that an according notification infrastructure can help informing private investors about relevant market events in time and reducing the quantity of sent messages to a manageable dimension.

DATA AND SAMPLE SELECTION

This study covers ad hoc disclosures pursuant to section 15 of the German Securities Trading Law (WpHG) as the event to focus on. Section 15 regulates in which business transactions a listed company has to publish an ad hoc disclosure. The observation covers all disclosures published by the Deutsche Gesellschaft für Ad-hoc-Publizität (DGAP) between 2003-08-01 and 2003-12-31 on behalf of the companies. The publication itself is done in more than ninety-five percent of all published ad hoc disclosures in Germany by DGAP. Several news agency partners make sure that the circularization of the announcements is guaranteed. I chose the DPA-AFX news feed, which contains among other news all ad hoc disclosures published by the DGAP. The data sample of the observation period consists of 1086 ad hoc disclosures. Each disclosure provides a timestamp exact to the second, which allows an automated processing and storage of the corresponding intraday stock price series of the publishing company. This approach allows the data processing of intraday price series, which were taken from the electronic trading platform XETRA or the Frankfurt Stock Exchange (floor trading). XETRA covers around ninety percent of the entire security trading in Germany (Deutsche Börse Group, 2003).

Because I concentrate on short-term price reactions, only disclosures published during the stock exchange operating hours were taken into the sample. Furthermore, the absence of an opening reaction to overnight announcements can be expected (Francis et al., 1992). Because of the chosen stock price data source I disregard ad hoc disclosures published by companies whose shares are only listed outside of Germany. To avoid distortions by confounding events, companies publishing more than one disclosure per day were identified. The disclosures of that day and the respective company are excluded from the sample. With the purpose of measuring the stock price reactions caused by ad hoc disclosures, there must exist at least twenty price fixings (ticks) after the disclosure. Furthermore, identical announcements published in different languages have been treated as only one announcement and test announcements have been ignored. These filter rules reduce the sample size to 110 ad hoc disclosures and the corresponding intraday price series, starting ten days before and ending at the announcement date. The nine days before the observed event are defined as comparison period whereas the date of announcement publication is defined as day of the observed event.

To be able to analyze price effects which were caused by the disclosures, observed returns have to be adjusted by general market developments. This adjustment is done by using the CDAX (ISIN: DE0008469602) market index as general market benchmark. The CDAX index contains all listed domestic companies (segments Prime and General Standard). Consequently it represents the entire range of the German equity market.

Given the price series of all stocks and the CDAX market index (exact to the second), I aggregated stock prices and CDAX prices which were fixed during the same minute to one price information (last price fixing). This procedure allows comparing stock price and general market developments automatically because of consistent time stamps exact to the minute.

This means that depending on the number of price fixings received from the stock exchange, up to 11 hours * 60 minutes * 9 days = 5940 prices per announcement were taken into account.

PRICE EFFECT ANALYSIS

At first, the discrete returns for all i stock price series (of the company which has published the ad hoc disclosure) at time t are calculated using the intraday prices P starting ten days before the day of the ad hoc disclosure.

$$R_{i,t} = \frac{P_{i,t+1} - P_{i,t}}{P_{i,t}} \quad (1)$$

These discrete returns were calculated for the CDAX index accordingly. In order to isolate the price effect caused by the ad hoc disclosure, I calculate net-of-market-returns. This adjustment is done by subtracting the index (CDAX) returns from stock returns $R_{i,t}$, which leads to abnormal returns ($AR_{i,t}$).

$$AR_{i,t} = R_{i,t} - R_{CDAX,t} \quad (2)$$

These net-of-market-returns assume a beta of one between stock *i* and the CDAX index. An examination of the quality of different return-generating models for calculating abnormal returns has shown, that the single index model I use leads to equivalent results as the more complex market-adjusted return model (Klein and Rosenfeld, 1987).

Because I do not make an ex ante classification of positive and negative announcements, the absolute value of $AR_{i,t}$ has to be taken ($AAR_{i,t}= |AR_{i,t}|$). $AAR_{i,t}$ can not be taken for any statistical tests, because rejecting the null hypothesis that 'a sum of absolute values is zero' would be possible with the utmost probability. Therefore $|AR_{i,t}|$ has to be reduced by an average of absolute abnormal returns which can be observed when no announcement is published.

This average absolute abnormal return ($AAAR_i$) is calculated for the comparison period, starting ten days before the disclosure timestamp. The announcement date and previous day are excluded because of possible insider trading price effects.

$$AAAR_i = \frac{\sum_{t=1}^{T} \left| AR_{i,t} \right|}{T} \quad (3)$$

The absolute abnormal returns $|AR_{i,t}|$ of the event day have to be adjusted by this average absolute abnormal return, which occurs when no announcement is published (Carter and Soo, 1999). The result is called the corrected absolute abnormal return ($CAAR_{i,t}$).

$$CAAR_{i,t} = \left| AR_{i,t} \right| - AAAR_i \quad (4)$$

This $CAAR_{i,t}$ is calculated for each timestamp *t* of the available price fixings. In order to examine the price reaction following an ad hoc disclosure, we have to sum up these $CAAR_{i,t}$ for defined time frames (*t1,t2*). These cumulated corrected absolute abnormal returns ($CCAAR_{i,t1,t2}$) have to be calculated for every stock price series and time frame. I calculated $CCAAR_{i,t1,t2}$ for (*t1,t2*) = (1,2), (5,10), (10,15), (15,20) whereas *t1* is defined as the timestamp of the first price fixing available after the announcement time and *t2* as the timestamp of the last price fixing of the observed time frame. This is done in order to prove the existence and the persistence of abnormal price reactions following the ad hoc disclosures.

$$CCAAR_{i,t1,t2} = \sum_{t=t1}^{t2} CAAR_{i,t} \quad (5)$$

The $CCAAR_{t1,t2}$ of a time frame (*t1,t2*) is the sum of the absolute abnormal absolute returns which can be observed within this time frame, e.g. $CCAAR_{1,10}$ would be the sum of the corrected absolute abnormal returns calculated for the first ten price fixings following the announcement. $CCAAR_{t1,t2}$ is calculated for different time frames (*t1,t2*) in order to prove in which time frames abnormal price reactions can be observed.

This $CCAAR_{i,t1,t2}$ has to be calculated for each time frame and ad hoc disclosure (corresponds with stock price series). All calculated $CCAAR_{i,t1,t2}$ of one time frame (*t1,t2*) can be interpreted as a distribution of *CCAAR's* (with a sample size of 110). Having the distributions for all four time frames, the statistical significance of the abnormal returns within these time frames can be evaluated. The null hypothesis H_0 to be proven is that $CCAAR_{t1,t2}$ is equal to zero.

$$H_0 : E\left(CCAAR_{t1,t2}\right) = 0 \qquad \text{vs.} \qquad H_1 : E\left(CCAAR_{t1,t2}\right) > 0$$

The distribution of $CCAAR_{t1,t2}$ must not be normal, but having a sample size greater thirty, the distribution of the sample means is approximately normal (Groebner et al., 1999). For each time frame (*t1*,*t2*) a *T*-test has to be performed. If the hypothesis H_0 can be rejected for a time frame, the abnormal returns for that time frame can be assumed to have a relatively high level of significance.

EMPIRICAL RESULTS

An efficient capital market should react to new information very quickly (Patell and Wolfson, 1984). Consequently there should be significant abnormal returns within the first observed time frames. Therefore I perform four tests regarding the significance of the abnormal returns for the time frames (*t1,t2*) = (1,2), (2,5), (5,10), (10,15), (15,20) (*** indicates significance on the 1% level; ** on the 5% level).

	$CCAAR_{1,2}$	$CCAAR_{2,5}$	$CCAAR_{5,10}$	$CCAAR_{10,15}$	$CCAAR_{15,20}$
Mean	0.0346	0.0104	0.0132	0.0050	0.0021
T-Value	3.71***	2.96***	2.32**	1.12	0.55

Table 1. Intraday price changes after ad hoc disclosures

As shown in table 1 abnormal returns can be observed for the first ten price fixings at a significance level of 1%, 1% and 5% after the ad hoc disclosure is published. This finding confirms a very quick reaction of the capital market to new information available. As a first result we see that a mobile information system would have to inform within this first ten price fixings. The corresponding cumulated corrected absolute abnormal return $CCAAR_{1,10}$ can be calculated using quotation (5) with (*t1,t2*) = (1,10) and has a *T*-Value of 4.27 (significance level of 1%). The sequential time frames in table 1 guarantee that the abnormal return significance can be assured for the entire time frame (1,10) ($CCAAR_{1,20}$ would also be significant, but $CCAAR_{10,15}$ and $CCAAR_{15,20}$ are not). Depending on the affected stock and the according trading volume, these ten prices are fixed within different time frames (measured in minutes).

PRICE EFFECT ESTIMATION

In order to implement a suitable mobile information delivery, a capable information system would have to regard two dimensions of the price effect caused by an ad hoc disclosure. First, it has to be proven if an announcement will have a significant impact on the stock price. If this can be negated, the notification of the investor is not mandatory. Also it is imaginable, that the investor defines an abnormal return limit. Only if this limit is exceeded, the investor gets notified. Secondly, the system should be able to estimate when the significant price reaction will be completed.

For estimating the abnormal price effect and the adjustment speed I have chosen the variables $CCAAR_{1,10}$ (cumulated corrected absolute abnormal returns of the first ten price fixings) and $\Delta min_{1,10}$ (number of minutes in which the first ten price fixings can be observed) as dependent variables, because they correspond to the observed significant price effects. These dependent variables should be explained by independent variables. Prior studies confirm a relationship between firm size (Zeghal, 1984), observed trading volume (Bamber, 1986) and the information content of company announcements.

Consequently, I have chosen market capitalization (logarithm taken) in million Euros at the date of the ad hoc disclosure publication. The second one is a dummy variable, getting a 1 if the company is member of the DAX (ISIN: DE0008469008), MDAX (ISIN: DE0008467416) or the TecDAX (ISIN: DE0007203275) index at the announcement date, and 0 in all other cases. The number of analysts covering the company is taken as next variable and provided by JCF Group (dated 2003-12-31). As these quantities do not fluctuate much over time, the loss of accuracy remains limited. The forth explanatory variable is the number of stocks issued by the company. The last is the trading volume (logarithm taken) of the previous trading day.

Because the chosen explanatory variables might be correlated (e.g. there is a positive correlation between market capitalization and trading volume) I performed stepwise multivariate ols regressions. Table 2 summarizes the results (*** indicates significance on the 1% level; ** on the 5% level; * on the 10% level; -/- not significant).

This analysis leads to the following correlation between the publication of ad hoc disclosures and the price effects and effect delay:

$$E\left(CCAAR_{1,10,i}\right) = 0.3336 \cdot \ln\left(marketcapitalization_i\right) + 0.2846 \cdot \ln\left(tradingvolume_i\right) \quad (6)$$

$$E\left(\Delta \min_{1,10,i}\right) = 262.5448 - 0.4628 \cdot \ln\left(marketcapitalization_i\right) + 0.2632 \cdot issuedstocks - 0.4256 \cdot \ln\left(tradingvolume_i\right) \quad (7)$$

Price effect ($CCAAR_{1,10}$)	constant -/-	In(market cap)	Index member (1 =yes; 0=no)	no. of analysts	no. of issued stocks	In(trading volume)
beta		-0.3336***	-/-	-/-	-/-	0.2846***
Effect delay ($\Delta min_{1,10}$)	constant 262.5448***	In(market cap)	Index member (1 =yes; 0=no)	no. of analysts	no. of issued stocks	In(trading volume)
beta		-0.4628***	-/-	-/-	0.2632**	-0.4256***

Table 2. Stepwise multivariate regression results using a probability-of-F-to-enter the regression model ≤ .050 and a probability-of-F-to-remove ≥ .100.

Quotation (6) provides an estimation regarding a forthcoming price effect if an ad hoc disclosure is published. This information can be used to evaluate if an announcement is relevant or not. Quotation (7) estimates the minutes after which the price reaction will be completed. If too short, a notification might not be reasonable. Furthermore, it can be used to evaluate the urgency of a notification. A shorter (longer) estimation would increase (decrease) the degree of urgency. In order to reduce prediction errors and to increase the forecast accuracy, the computation of the explanatory variables has to be done on occasion. Also a new determination of the explanatory variables has to be done for other capital markets.

MOBILE INFORMATION INFRASTRUCTURE

The goal of the proposed mobile notification services is to provide the right information at the right time over the right mobile channel in order to enable investors making better contemporary investment decisions. Another goal is to reduce the level of user-intrusiveness by notifying about relevant events only. In order to achieve these goals the attributes price effect and effect delay were introduced. In the next section I propose a notification model in order to make the automation of the notification process possible. After this, a capable notification system infrastructure is introduced.

Notification Model

The goal of this notification model is to define rules which make an automated processing of new ad hoc disclosures possible. This is done by going through a five step valuation process. In a first step, it has to be proven if a new announcement is relevant for the investor. Consequently a notification will be discarded if the announcement is published by a company whose stocks are not hold by the investor. Otherwise, an estimation of forthcoming effects evaluates if a notification is required or not.

In the second step the estimation of the price effect and the effect delay is done via quotation (6) and (7). Only if the price effect is larger than a fixed limit (e.g. $CCAAR_{1,10}$ > 0.5%), a notification is sensible. Furthermore, there must be a minimum of reaction time (e.g. $\Delta min_{1,10}$ > 5 minutes) or the investor will not be able to react in time. This applies in most cases to stocks mainly traded by institutional investors. If the investor is not able to react within the calculated maximum reaction time, the notification will expire. This prevents that the investor has to navigate though several outdated notifications. Only if there is a significant price reaction expected and there exists enough time to react, the investor will be notified.

In a third step, there is a valuation of the event relevance in order to derive a priority level. The higher (lower) the estimated effect delay, the lower (higher) will be the priority level. It is sensible that the investor fixes stepped limiting values before, so the degrees of urgency can be defined by the investor. The effect delay influences also the notification priority. If there is a plenty of time to react (because the expected $\Delta min_{1,10}$ is high), the priority will be lower than if there are only a few minutes reaction time left.

The next step depends on the findings of the previous step. According to the priority level determined, the investor gets informed via different notification content. If there are only few minutes left to react, the investor gets informed about the relevant announcement including the estimated price effect and effect delay. Furthermore, the notification contains a buy/sell link only to enable the investor making a transaction in time. If there is a relevant price reaction and plenty of reaction time expected, the notification contains besides the effect estimations additional links which contain further information (e.g. charts, company profiles or risk management information).

Finally, if the event has been identified as relevant, the notification is sent to the mobile device of the investor. Besides the notification content, the message contains additional meta information (priority and expiration date). Figure 1 illustrates the notification model using a Unified Modeling Language (UML) Activity Diagram (Fowler, 2004).

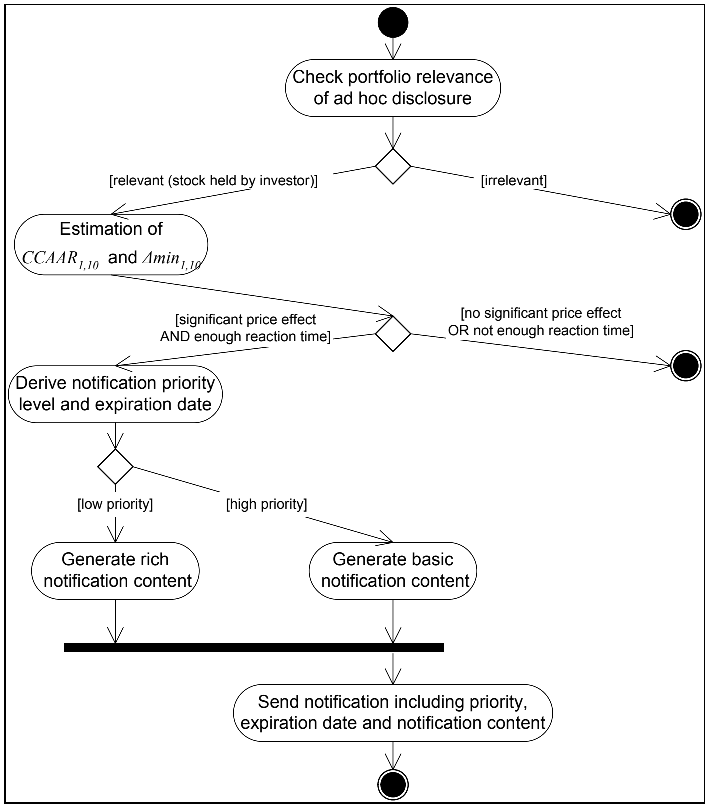

Figure 1. UML Activity Diagram of the Notification Model

As demonstrated, the investor will be notified in relevant situations only. Furthermore, the defined expiration date helps reducing level of user-intrusiveness by permitting the deletion of already sent but meanwhile outdated notifications. The personalized notification content helps the investor in making an investment decision in time.

Notification System Infrastructure

In this section a system infrastructure is proposed which covers the notification model described. In a first step the investor configures the notification limits via web browser. This configuration includes the limits for $CCAAR_{1,10}$ and $\Delta min_{1,10}$ at which a notification should be generated (e.g. $CCAAR_{1,10} > 1\%$ and $\Delta min_{1,10} > 5$ minutes). Moreover, the configuration contains limits to define a priority level for the notification (e.g. if $\Delta min_{1,10} < 15$ minutes the priority is defined as very high). The entire notification configuration is stored on the Portfolio & Limit Management Server (PLMS), which also stores the current portfolio status of the investor. In case of a new ad hoc disclosure is published (provided by a News Feed Server) this server checks whether the investor holds stocks of the company which has published the announcement. If so, the server estimates the values of $CCAAR_{1,10}$ and $\Delta min_{1,10}$ using quotations (6) and (7). These results will be compared with the user defined limit configuration. Only if this configuration matches with the estimated values of $CCAAR_{1,10}$ and $\Delta min_{1,10}$ a notification will be send.

For this scheme, I purpose the usage of the combined push/pull service called Service Indication (SI) which is part of the Wireless Application Protocol (WAP Forum, 2001b). A Service Indication (SI) is an application of the Extensible Markup Language (XML) 1.0 and provides the functionality to send pushed notifications containing notification attributes (e.g. expiration date). Furthermore, it links to a service which is usable via a pull request (e.g. for selling a portfolio position) (Mallick, 2003).

A push notification containing a textual Service Indication (SI) is sent by the PLMS to the Push Proxy Gateway. The following figure illustrates how a typical notification scenario and the according SI would look like.

Notification Scenario

1. The investor holds stocks of this company and has set notification limits to: $CCAAR_{1,10}$ > 1% and $\Delta min_{1,10}$ > 5 minutes. Furthermore an estimated $\Delta min_{1,10}$ < 15 minutes is defined as high priority.
2. Company XY publishes an ad hoc disclosure at 2004-06-20 at 10:23 am.
3. The portfolio and limit management server estimates a $CCAAR_{1,10}$ of 1.23 % and a $\Delta min_{1,10}$ of 12.5 minutes.
4. This event causes a Service Indication to be initiated.

Service Indication

```
<?xml version="1.0"?>
  <!DOCTYPE si PUBLIC "-//WAPFORUM//DTD SI 1.0//EN"
    "http://www.wapforum.org/DTD/si.dtd">
<si>
  <indication href="http://www.example.org/trade.wml?id=007007"
     created="2004-06-20T10:23:15Z"
     si-expires="2004-06-20T10:38:45Z"
     action="signal-high">

        You have 1 new notification

        User-intrusiveness level: high
        Expiration Date: 2004-06-20 10:38:45
        Company XY has published a portfolio relevant announcement
     </indication>
</si>
```

Figure 2. Service Indication (SI) Example

Because the investor defined that an estimated $\Delta min_{1,10}$ < 15 is a high priority event, the generated Service Indication (SI) has the attribute value "signal-high". The Push Proxy Gateway converts the XML text to a binary SI, which is send to the mobile device of the investor. Depending on the capabilities of this device, the SI might cause a pop-up window or is simply presented immediately (WAP Forum, 2001a).

If the investor decides that an event demands for further market research or buying or selling a portfolio position, the service URI can be used (actionable alert). This will cause a "WSP GET" request transmitted to the Method Proxy Gateway which converts into a "HTTP GET" request (Schiller, 2003) sent to the Portfolio & Limit Management Server. This server replies by sending e.g. a Wireless Markup Language (WML) document containing additional notification information. The textual WML document is converted by the Method Proxy Gateway into a binary WML document, which is sent to the investors' mobile device. This notification contains additional information regarding the ad hoc disclosure, estimated price effects and can link to other WML pages. These can provide further information or enable necessary portfolio transactions. The infrastructure described above is illustrated in figure 3, presenting all servers and devices concerned. Moreover, it includes all resulting communication processes.

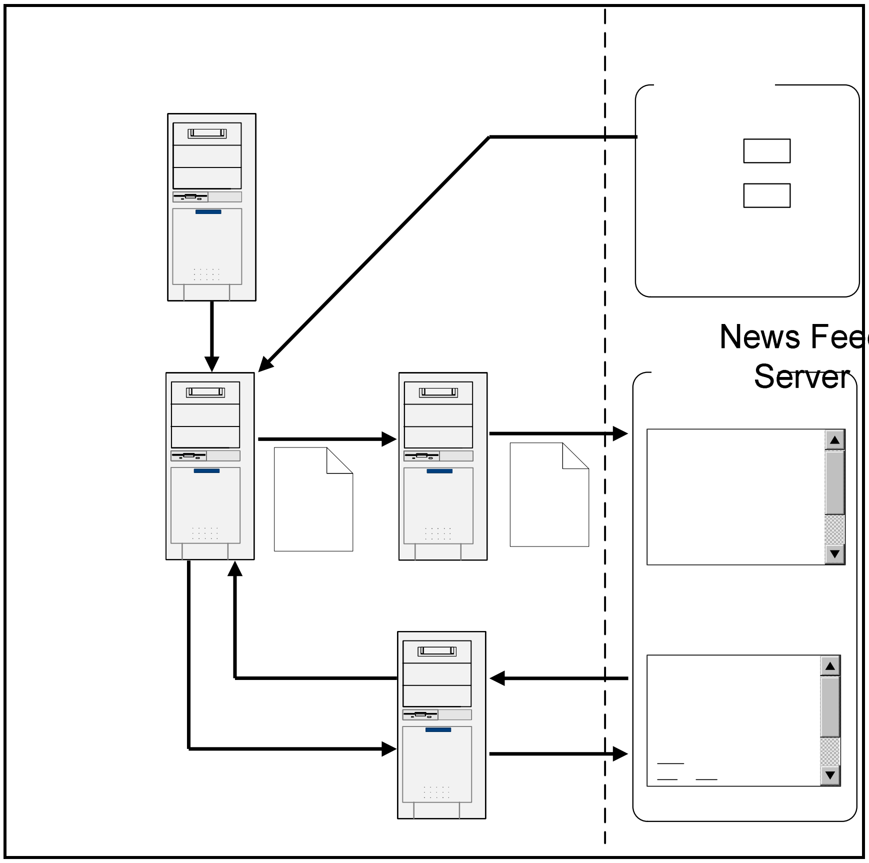

Figure 3. Notification System Infrastructure

With the proposed implementation using Service Indication the presented aims can be achieved. The push service SI facilitates a prompt notification of private investors in case of relevant market events. The usage of notification attributes allows defining priority level and expiration date. These functionalities are ideal to reduce the level of user-intrusiveness, because outdated notifications can be deleted automatically and notifications with low priority can be discarded or postponed. Furthermore, service URI links to relevant services enabling the investor making further market research or doing portfolio transactions.

SUMMARY AND CONCLUSION

The existence of significant price effects caused by company announcements asks for prompt notification of investors. Analyses of intraday price series and financial ratios illustrate that forthcoming price effects and effect delays can be estimated. Focusing on private investors the antagonism of prompt notification and level of user-intrusiveness is evident. This problem can be approached by estimating forthcoming price effects and applying notification limits fixed by the investor. Because private investors are not able to observe all relevant market events, a push notification via mobile device seems adequate. As the notification might require a prompt stock market order the proposed notification system infrastructure using the combined push/pull service called Service Indication (SI) can fulfil these requirements. Furthermore, the usage of SI attributes (expiration date, priority) can help reducing the number of sent notifications to a manageable dimension.

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