

# Anchoring News Events in Time

Earl J Wagner  
Northwestern University  
2133 Sheridan Road  
Evanston IL 60201

Praveen K Paritosh  
Northwestern University  
2133 Sheridan Road  
Evanston IL 60201

Lawrence A Birnbaum  
Northwestern University  
2133 Sheridan Road  
Evanston IL 60201

ewagner@northwestern.edu

paritosh@northwestern.edu

birnbaum@cs.northwestern.edu

## ABSTRACT

We present Newspique, a system for reading news online that retrieves articles to automatically generate a timeline for a topic and identifies subtopics for further exploration. To support the exploration of the context of an article, it converts each dated event description in an article into a hyperlink linking to an article about the event. The functionality of Newspique comes from an algorithm for ranking articles published on a day based on the number of references to the events of that day. We call this algorithm DateRank, in analogy to Google's PageRank.

## Categories and Subject Descriptors

H.3.3 [Information Storage and Retrieval]: Information Search and Retrieval – *Information filtering*. H.5.2 [Information Interfaces and Presentation]: User Interfaces – *user-centered design*.

## General Terms

Algorithms, Design.

## Keywords

News, Temporal clustering, Timeline.

## 1. INTRODUCTION

News is fundamentally temporal. Stories break, unfold and become stale over time. Readers use the date a news article was published to make sense of the events it describes. Gaining a deeper understanding of the overall situation often requires reading about related events, both before and after the article date.

The time course of events provides a powerful organizing framework for all the content about a topic. Consider the topic of the recent election in Germany. Articles published both within Germany and around the world described the campaigns of the main candidates to lead the country. The uncertain election results caused financial markets to slump and pollsters to reevaluate their methods, among other consequences. News sources including CNN and BBC produce retrospective in-depth reports for some situations like these, but many situations are not covered to this

depth.

Unfortunately, newspaper and magazine publishers have made little progress in supporting richer interaction with the content they produce and make available online. Online versions of news articles are typically print articles inserted into web pages. Though the body of an article refers to relevant events, it rarely links to other articles describing them.

News search engines such as Google News, Yahoo! and MSN retrieve a large number of news articles based on users' search query, but provide no semantic organization for the articles retrieved. One can copy the description of an interesting event from an article and paste it into a news search engine to find articles with the same terms. Sorting through the large number of search results that come back in order to discover what happened is tedious, however.

In this paper, we introduce Newspique, a system that supports understanding of news topics at a high-level by 1) automatically generating a timeline for events described in news articles returned by a search query, and 2) converting temporal references to events in articles into hyperlinks to other articles covering the events. It supports searches at various levels of detail, for example, one might be interested in the overall timeline for the election, or just the implications for financial markets.

Timelines are a useful way to present information that has a temporal extent. Reporters often generate timelines to describe the course of events in a certain situation. Little research has focused on generating timelines like these, however. We anticipate automatically generated timelines, even of somewhat lower quality, could be invaluable for navigating search results. Rather than browsing through article titles and snippets featuring keywords, a user could view and navigate descriptions of events themselves and interactively zoom in for more detail.

Newspique generates an interactive timeline for a corpus of articles retrieved used terms either supplied by the user, or extracted from the web page the user is currently reading. Through the timeline interface, it also shows the relative importance of various events and their descriptions. It supports inspection of sub-topics and drilling down for more detail in a interface overlaid on top of news search engines.

At the heart of Newspique is the DateRank algorithm. Working analogously to Google's PageRank, DateRank looks for sentences referring to events occurring on days, then uses the number of references to a day to establish importance. Later, the event reference sentences are summarized as labels for the events of the day.

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In section 2, we discuss the design space of technologies and interfaces to support news-reading online and list the requirements for a system to better support browsing the contexts of articles. Section 3 presents a usage scenario and describes the user interface elements of Newspique. Section 4 delves into the details of DateRank and presents an algorithmic sketch of how Newspique works. In section 5, we present an evaluation of the DateRank algorithm. Section 6 discusses related work and we end with conclusions and future work in Section 7.

## 2. BACKGROUND

In this section, we look at existing technologies and interfaces that support reading news online.

### 2.1 Links within News Articles

An informal analysis of the online versions of the world's twenty largest newspapers<sup>1</sup> discovered the affordances they provide for exploring an article's context. Very few of the newspapers provide any links to any other related stories. Only a small fraction provide links to a small number of (usually four or five) "related stories" in an adjacent panel, separate from the main story. Although these can be useful as background, the title of the related article alone may not provide enough information to know what aspects of the current article it elaborates. Appendix 1 lists a selection of the types of links provided for accessing more information.

Some newspapers process their articles, creating links for named entities within the text. For example a corporation name may link to the newspaper's web page profiling the business. Very few of the newspapers provide links to related stories within the content of the stories. Some online magazines like Slate and Salon.com do feature hand-annotated sentences with links to earlier articles.

Sometimes, for an important event, newspapers have a special handcrafted "digest" article that describes and links to related stories, pictures and multimedia. BBC provides a timeline for important stories, though the timelines often only describe the important events but don't link to stories about them.

High-quality, meaningful links embedded within article text and a timeline interface for visually organizing the events of a situation provide compelling, high-level means for interacting with an article. They are relatively rarely produced, however, because of the work required to manually construct them. Our goal with this work is to automatically provide links from event descriptions in an article to another article that more fully describes the event, and to automatically generate a timeline with meaningful labels explaining the events related to those described in the article. A further advantage of an automated approach is that the user can organize, on-demand, the information that she is interested in.

### 2.2 News Aggregator Websites

Web sites such as Google, Yahoo! and MSN aggregate news content from many sources. By searching on these sites, one can access a rich variety of news content about a topic in the news, with results being organized by date or relevance. In bringing together searchable news from many sources, these sites support easily reading different accounts of the same event. However,

navigating through thousands of stories returned for a typical search query is onerous.

This raises an important difference between searching general web pages as compared to searching news articles. Searching the web often involves finding the authoritative page for a concept, such as the home page for an individual or business. These mappings from concept to page do not change rapidly over time. On the other hand, the best description for a situation unfolding over time is typically the most recent summary. While the popularity of a summary increases over time, its usefulness diminishes as time passes.

While Google's PageRank and related algorithms are quite successful in providing relevant results for general web search, when it comes to ranking news search results, we are still in the pre-Google era. Ideally, articles would be organized in time, not simply by when they were published, but by the times of the *events* they describe. Later in the paper, we will discuss DateRank, an algorithm we have developed to automatically organize articles by the events they describe.

### 2.3 Clustering of Search Results

Systems like Clusty<sup>2</sup> help the user navigate search results by clustering hits based on term frequencies. These systems however only support a limited depth of searching.

News articles are important along an additional dimension beyond just topic. Unlike interpreting a web page, interpretation of a news article necessarily involves knowing when it was published, and when the events it is describing happened. Clustering approaches based just on content do not take time into account. Content based clustering approaches [Zamir and Etzioni, 1998] are good at reducing the large number of search results, but the clusters thus produced do not have the temporal coherence that is needed for a domain like news.

The events that make up a situation are anticipated and have consequences over time. We argue that the situation can be characterized in terms of the most prominent events that it encompasses. Thus in exploring a situation, it can be helpful to have a decomposition of the situation in terms of the lifetimes of various events that make it up.

A search on Clusty results in a set of six clusters based on the content of the stories, but they have no temporal order. Reading news involves building a mental model of the unfolding and causation, and temporal order and coherence of clusters found is crucial and missing in a content based clustering approach.

### 2.4 News Summarization

Within the domain of text summarization, algorithms have been developed for summarizing news articles. Like clustering based on content, we see this as separating the event descriptions from an important aspect of context, the source. News summarization obliterates these distinctions. A key aspect of news is where, how, and by whom it was produced – whether it comes from the New York Times, Fox news or a weblog.

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<sup>1</sup> Compiled by World Association of Newspapers, and available at <http://www.wan-press.org/article2825.html>

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<sup>2</sup> <http://www.clusty.com/>

The techniques used in systems like NewsBlaster, NewsInEssence and DEMS [Schiffman *et al*, 2002] are very useful and we are using a similar approach in the Newspique engine to compute document similarity and constructing labels for sub-topics found. In contrast with the summarization approach, Newspique leaves relevant articles untouched; it organizes but doesn't tamper with content.

## 2.5 Other Approaches

Krakatoa Chronicle [Bharat *et al*, 1998] generates a virtual newspaper with an appearance similar to print newspapers featuring multi-column layout and justified text. Bharat then went on to build Google News, which aggregates approximately 4,500 news sources. The layout and organization of Google News is completely automated. This is the first piece of technology that makes it extremely easy for the reader to see what has been published on a topic in different sources.

Rob Allen's Event Gazetteer system presents a query interface to a database of events. Each event has various attributes, including pointer to subevents. The system generates SQL queries in response to user queries about events. Lifelines [Plaisant *et al*, 1996] presented a front-end interface for displaying data that is explicitly time-tagged, like medical records. The Historical Event Markup and Linking (HEML) project [Robertson, 2002] provides tools to manually encode temporal information that can be rendered into hypertext timelines.

## 2.6 Desiderata for a news reading system

Based on the above discussion, here we lay out a checklist of features a news reading system must be able to support:

1. *Temporal organization*: Use time as the salient dimension to organize articles.
2. *Variable resolution timeline*: The algorithms and the interface must support looking at different timescales and levels of resolution, e.g. events like the Katrina hurricane that unfold over a few days versus Gaza pullout where the interesting points are spread out over more than a year.
3. *Support user context*: People are interested in various aspects of news, and the system must be able to organize the results according to information needs of user.
4. *Responsive*: The system should work incrementally and be responsive.
5. *Simple interface*: Meaningful labels, intuitive interface with minimal novel elements, repurpose existing interface elements/visualization and interaction techniques.

## 3. USAGE SCENARIO

Newspique is implemented as an extension to the Firefox web browser. Much like the Google toolbar, it provides a search box

through which the user enters a query. The query results are visualized as an interactive timeline grid within the toolbar. Additionally, the browser extension monitors the web page the user is currently viewing to provide additional means for navigation. It recognizes sentences in the article content with absolute and relative date references. It then converts each sentence into a hyperlink the user can click to load an article covering the event the sentence describes. Each link has as a tooltip the title of the linked-to article. (Figure 1)

Consider an example in which a user has loaded a typical news article. The system extracts the most common terms from the text of the article, and provides them as search terms in the search box at the top left of the tool bar. The user clicks search and, after retrieving relevant articles, the system displays the timeline it generates. (Figure 2). Reloading the current page after the system's searching allows the user to interact with the hyperlinked references within the text, as in Figure 1.

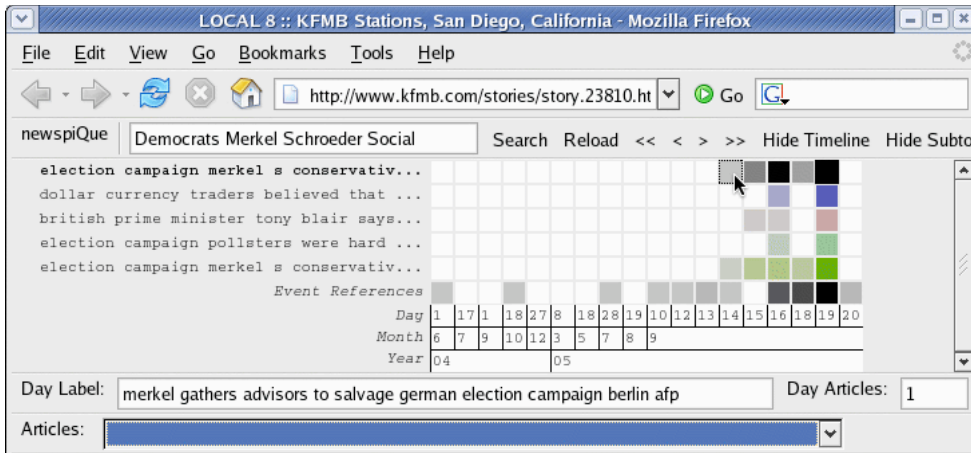
The timeline is presented as a grid with labels on the left-hand side. The top label, in bold, summarizes the events described in all of the articles retrieved. In this case, the label for all of the articles retrieved about the German election is "election campaign merkel a conservative...". Below the label summarizing all of the articles are labels summarizing each sub-topic, including "dollar currency traders believed that an inconclusive german election threatens".

To the right of the overall topic and sub-topic labels are rows indicating when articles discussed these topics, ordered by day. The days with more articles discussing a topic are more saturated while days with fewer are greyer and days with none are white. In addition to the overall and sub-topic labels are labels for the Event References row, as well as labels indicating day-of-the-month, month and year (last two digits). The Event References row of the grid shows how many references there are to a particular day by saturation. This provides a rough guide to the important days.

The user views descriptions of days by moving the mouse over the cells of the timeline grid. (Figure 3) The "Day Label" text box below the grid shows the summary label for all the articles published on that date for that sub-topic, and the "Day Articles" text box shows the number of articles for the sub-topic on that day. Clicking on the cell loads the "Articles" pull-down menu at



Figure 1. Sentence with an event reference annotated with a link



**Figure 2.** Moving the mouse over a timeline cell to view an explanation of the topic and day event.

the bottom of the toolbar with the cell's article titles. Selecting a title loads the article in the browser window.

#### 4. ALGORITHMS

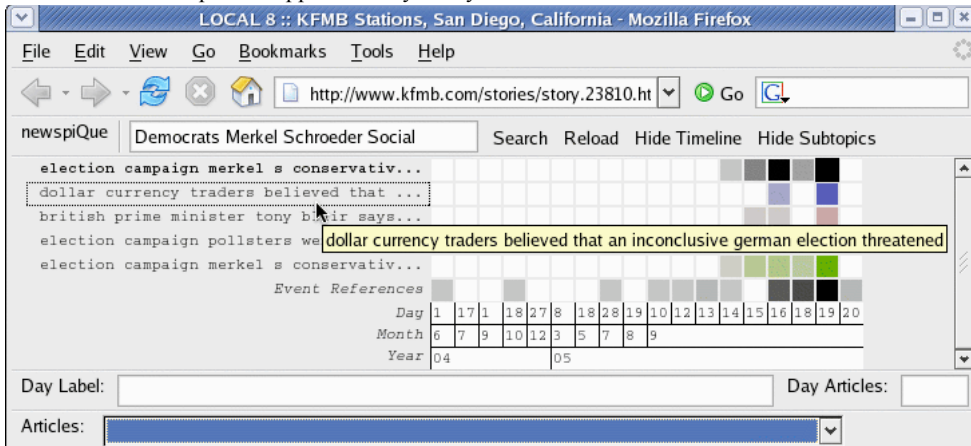
The first step in creating a timeline is making a list of the important dates. In this section we describe the DateRank algorithm for automatically identifying the important dates for a corpus of articles.

Much implicit structure in news articles is currently not being exploited by news search engines and interfaces for reading news. This structure takes the form of dated event references: sentences that describe an event as happening on an absolute or relative date references, e.g., "September 12" or "next Monday," respectively.

Just as PageRank uses the number of links to a page and the text used in those links to describe the page to establish the importance and meaning of the page, DateRank uses the number of references to events on a given day to determine the most important dates of a situation. We now look at how it extracts these date references and later turn to how it uses them to parameterize further searches.

##### 4.1 First phase: create an initial corpus of articles

After an initial corpus of approximately thirty to one hundred



**Figure 3.** Mouse over ellided subtopic label shows entire label

articles has been retrieved, the system extracts all of the dated references in the bodies of the articles and assembles an "event reference" timeline in which each day is associated with the references to it.

The system extracts the content of an article by finding the longest sections of text with the least HTML markup. The text inside the article page title tag is used as the article title, and through regular expressions, the system finds the publish date of the article as first date in the page. It splits the article content into sentences and scans the sentences using regular expressions

to find absolute and relative date references. The system recognizes simple references of the form "September 12<sup>th</sup>" and "next Monday" and associates them with a date. It treats references to "next week" and "last month" as references to the first date in the range, and is unable to recognize phrases such as "this past weekend" and "one day before."

Once we have extracted all the date references, we cannot merely select the days with the most references as these days may be contiguous in time. Instead we look for dates spread out over time in which the number of references peaks or starts a plateau. The system finds these by taking the derivatives of the number of event references and finding the zero points. It then sorts these peaks by decreasing number of event references and selects a predefined number, currently the first four.

##### 4.2 Second phase: expand the corpus around important dates

As we argued earlier, for news articles it is important to cluster based not merely on content but date as well. Through applying the DateRank algorithm we find the important dates and use these to constrain clustering to articles only in the vicinity of the date.

In the second phase we retrieve more articles with the original search terms published between one day before and two days after the event, for each of the event peaks. This date range retrieves stories anticipating an event, as well as stories describing an earlier event. The system then uses the event peaks for cluster seeds provided as input to k-means for clustering the articles. With this approach, each article is assigned to the subtopic to which it is most relevant.

### Overall algorithm

1. Find date references and peaks using DateRank
2. For each peak, query news search engines for articles around day
3. For each peak create a cluster seed with the concatenation of
  - a. the sentences referring to this day
  - b. the titles of the retrieved articles
  - c. the leads of the retrieved articles
4. For each article and cluster seed, create a tf-idf vector from its content.
5. Apply k-means to cluster articles by tf-idf vectors
6. Assign labels to clusters
7. Render timeline

Figure 4. Outline of Newspique algorithm

## 5. EVALUATION

A complete user evaluation is needed to determine the usability of the Newspique system. In this work, we have focused on building the algorithmic and interface infrastructure needed to support reading news as laid out in the Section 2.6, and a detailed user study is forthcoming.

Table 1. Timeline for the 2005 German Elections.

Date	Event	Distance from the nearest DateRank peak	Distance from the nearest ArticleRank peak
07/01/05	Schroder loses vote of confidence	0	n/a
07/21/05	Kohler dissolves Bundestag	0	n/a
08/25/05	Federal court rejects injunction against vote	0	-1
09/04/05	Debate	0	+3
09/08/05	Candidate of National Democratic Party dies	+1	-1
09/18/05	Election day	-2	0
10/02/05	Postponed election date	0	n/a

In this section we present an evaluation of the DateRank algorithm. A key claim of the DateRank algorithm is that references to days in other articles provide a good metric for ranking their importance. One common alternative consists of determining the importance of a day based on the term frequencies of articles on following days. Another approach is to look at the number of articles about a topic published on a certain date as the indicator of importance of the date.

To evaluate the effectiveness of DateRank, we compare it to this latter “article frequency” algorithm, or Article Rank. We look at the German election example.

Table 1 lists the important events involving the German Parliamentary election of 2005 according to Wikipedia<sup>3</sup>. For each of the events, we list the distance from date to the closest peaks computed by DateRank and Article Rank. A distance of zero indicates that event date is a peak. Note that DateRank found event dates beyond the range of the dates of articles retrieved.

The number of date references and article frequencies from DateRank and Article Rank respectively are plotted on Figure 5. The y-axis is the log of the normalized frequency.

## 6. RELATED WORK

### 6.1 Autonomous contextual search

Watson [Budzik and Hammond 1999] extracts the content of documents the user is currently viewing and editing to search for related pages on the web.

### 6.2 Temporal information processing

TimeMine [Swan and Allan 1999, 2000] provides a user interface that organizes a corpus of time tagged articles along a timeline. They start with a large corpus, a year’s worth of news articles in their example, with the goal of automatically constructing a “Year in Review.” TimeMine finds clusters of terms that are indicative of major news topics by finding terms that occur relatively more frequently on some days than others. Documents are represented by bag of features which are noun phrases and named entities, and their arrival is modeled as a random process with an unknown binomial distribution. Using chi-square tests, they detect statistically significant associations between features and time periods, which are then grouped into clusters based on association between features. Based on a human evaluation, they conclude that their approach discovers the important topics in the corpus, but acknowledge that the labels for clusters were of poor quality. Also, they were not concerned with the task of reading news articles, but with batch retrospective analysis of a large corpus.

Chieu and Lee [2004] present a system for extracting events relevant to a query from a corpus and placing them along a timeline which combines Swan and Allen’s idea with a sentence level analysis of the corpus driven by a user query. They start with finding all sentences in the corpus that mention the query term(s), which are then ranked by *interest* and *burstiness* to generate the timeline. The *interest* metric for a sentence is how many other sentences report the same event, and the *burstiness* metric captures the frequency of an event being mentioned during a duration, and not being mentioned outside of the duration. Sentences are mapped to vectors of term frequency where an iDf (inverse date frequency) weighting is used to weight terms, which is computed from the sentence corpus. A dot product between two sentence’s vectors is used to infer if they describe the same event. In the last phase of processing, duplicate sentences are removed since the ranking results in many sentences that are similar or identical at the top of the list. They do that by deleting events that are “near” each other on the timeline. For any sentence, they define its *extent* as the time interval in which its interest is more

<sup>3</sup> [http://en.wikipedia.org/wiki/German\\_federal\\_election\\_2005](http://en.wikipedia.org/wiki/German_federal_election_2005)

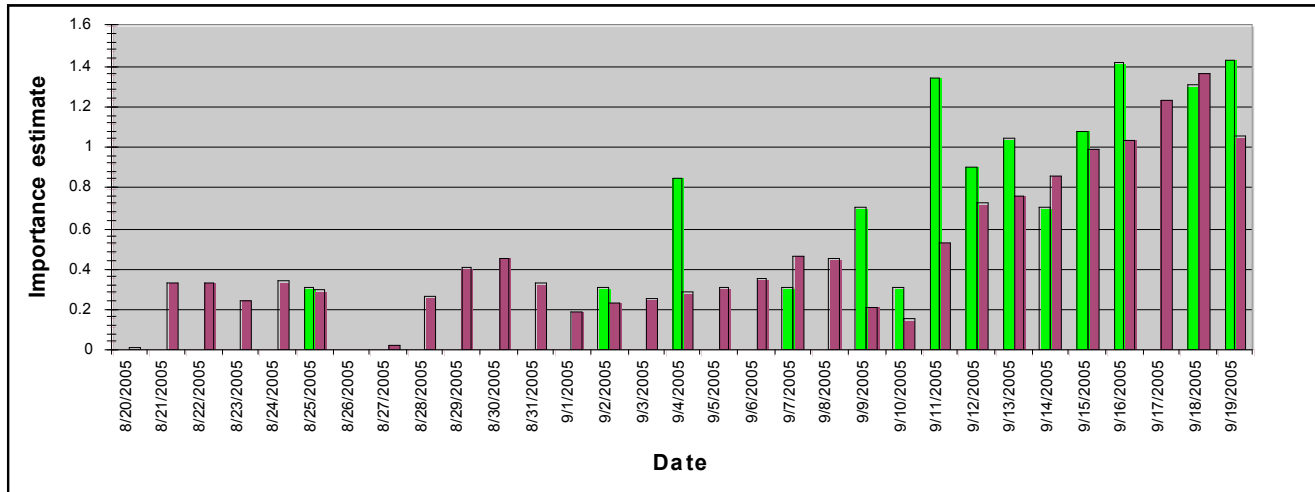


Figure 5. A comparison of DateRank (green) with Article Rank (red)

than a certain fraction of its interest in a ten day period around the sentence.

In this approach, all sentences in their corpus **must** contain at least one of the query terms. However, many of the interesting events will be missed out using this heuristic. For example, events related to the German election might be talking about “Angela Merkel”, “Bundestag”, or the “financial markets”. Their system makes implicit assumptions about the timescale at which interesting things happen, for example, their algorithms have a constant T, which is set to 10 days in their examples – the interest, burstiness and extent metric are computed for this T. In reality, news contains events that unfold over a period of years and those that unfold over a few days. Also, the reader might want different levels of temporal detail. Our method of computing local maxima in the event references timeline is similar to their burstiness, but does not make assumptions of timescale.

Uejima et al (2004) addressed the problem of estimating a timestamp for an article using a collection of articles that contain temporal aspects. They use clustering based on bag of nouns and proper noun words extracted by Brill tagger, and an exponential decay in weight of features over time.

Bell (1999) has pointed out that temporal structure of news is dictated by perceived news value than chronology with the latest news being presented first, with the possibility of multiple backward and forward movements through different time-frames. Mani’s work on linguistic analysis of temporal references in news text. TimeML.

Another line of related work is from the Topic Detection and Tracking (TDT), where one of the goals is to detect the occurrence of a new topic and track stories on known topics [Papka and Allan, 2000] as they evolve by analyzing time tagged streams of broadcast news.

## 7. CONCLUSIONS AND FUTURE WORK

The goal of the work presented here was to build the algorithmic and interface elements needed to support reading news. The next step is to carry out user evaluation of the system.

Some of the issues for future work are:

1. Personalization: Having a user model to provide interface and content tailored to her [Billisus and Pazzani, 1998] will increase the usefulness of the system.
2. Automatically finding the number of event peaks that are important: We use a fixed number of maximas, currently four, in the timeline to provide the basis for the initial cluster centers. Ideally, we have a knob, or an automatic mechanism that tells us how many peaks matter.
3. This system provides a great testbed to experiment with ideas about keeping track of persistent, ongoing user context.

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## Appendix 1: Affordances provided by online versions of the most widely circulated newspapers.

News Source	Links in body	Related links	Digest versions	Others
The Daily Yomiuri	None	None	None	
Asahi Shimbun	None	None	None	
People's Daily China	None	On the side, sorted by date, oldest first.		
The Chosun Ilbo	None	None	None	
USA Today	Related audio, graphics and video, explicitly marked "Related:." Some handpicked related stories.	Manually assembled set of related links on the right side for developing stories	Yes. "Aftermath of Hurricane Katrina"	
Daily mail	None	None	None	
Times of India	None	At the bottom of the story		
New York Times	Country: stories about that country US States: links to local news Company: page with stock price and other financial data	Related stories and multimedia in a separate panel on left.	"Complete coverage"	Links to readers opinion
BBC News	Inset graphics/quotes with links, no links in the body text.	Related stories and much more in a panel on the right	Manually constructed timelines for key events	In-depth Key stories Features and analysis, Links from other news sites
CNN	Links to full story and multimedia In the business section (CNN Money), some hyperlinks to stories earlier published, links to stocks/finance page for company names, and links to research reports on companies.	Top panel, above headline: link to explanatory background material. Right panel, related links, multimedia.	"special report": a collage with pictures, video.	"full story" a detailed, earlier story