S$_2$N: Safe Satellite Navigator

Shahzad Nizamani[1], Mohsin Memon[1], Muhammad Akram Sheikh[2]
and Areej Fatemah[1]

[1]Department of Software Engineering, Mehran University of Engineering and
Technology, Jamshoro, Pakistan
[2]Pakistan Scientific and Technological Information Center (PASTIC)

Abstract

Satellite navigation (Sat Nav) systems have revolutionized the way we travel as no longer does one need to remember the routes or to ask for directions. Majority of such systems use A* algorithm to identify the shortest route. The issue with current systems is: "Is the shortest route the best route?" As in case of Iraq, Syria, Yemen, Afghanistan, Columbia, Mexico, Somalia, Pakistan and numerous other countries choosing a route can simply be the difference between life and death itself. This paper proposes the Safe Satellite Navigator (S$_2$N), which will identify the safest and the shortest route. The selection process would be based on data from online (news/social media/blog), traffic, and crime data sources. The paper identifies an extensive list of parameters which affect the route selection process. The paper also proposes mechanisms for extracting, storing and processing such information. The system architecture of the proposed S$_2$N framework is also incorporated in the paper. The selection process is subdivided into three steps, step1 identifies the shortest route. The second step involves evaluating each street on the selected route for security concerns. The third step involves the final selection. If the selected route does not meet the minimum security requirements an alternative would be selected by repeating the first two steps.

1. Introduction

Sat Nav systems have replaced the age old method of tackling paper maps and coming up with a route which had caused many anguish and delays. Majority of the cars in the developed world are either fitted with a built-in navigation system or use alternatives as TomTom or Garmin which are easily available in the market. This however is not the case with the developing nations where the key priority is having cheaper cars. The cost is so important that even air bags are not included in most cars let alone a built-in navigation system. The only options for citizens of such nations is to use navigation apps such as MapFactor, Sygic, waze, and Navmii. All Sat Nav systems provide autonomous geo-spatial positioning with global coverage. These systems rely on Global Positioning System (GPS) for the user's current position. Which is returned from the GPS satellite in terms of longitude and latitude. This position information is fed into a route calculator which uses A* algorithm for calculating the shortest route to user's destination [1,2].

Traditionally a drivers calculate the ideal route by taking into account numerous parameters these depend on his location and the time of the day. The driver would take into account parameters such as distance, quality of road, congestion, and the level of safety on that particular route. The level of safety is a very important concern for many drivers as numerous cities around the globe are plagued by rampant street crime. Take the example of Detroit, Capetown or Karachi where every years thousands of people face

violent crime on the roads. A recent survey conduct by Gallup and BBC Pakistan identified that half of the resident of Baldiya town Karachi had their mobile phones snatched. The survey identified each area of Karachi by the type of criminal activity taking place there. While Gaddap town Karachi was termed as the capital of carjacking. [3]

World Wide Web is a remarkable source of information as news travels fast and one can easily access news regarding any event occurring where at any time. There are two main sources of information on the Web. These are the mainstream new channels like BBC, CNN among others each of which maintain a very extensive website with all the latest news. The other source of information is the blogs/forums these are maintained by the public. People share their experiences on these blogs/forums. [4,5]

This research involves gathering traffic data from multiple sources. These include crawling the news websites and blogs/forums, CCTV data, historic traffic data, historic crime reports. All of this data would be processed for identifying the safest and the shortest route for a driver. The aim of this research is to create a security aware risk free navigation framework. The key objectives of this research are as follows:

1. Identifying the parameters which affect the route selection process.
2. Identifying the sources for extracting parameter information.
3. Extracting/processing information from the identified sources
3. Designing the S_2N Framework
4. Development of S_2N prototype
5. Evaluation of S_2N prototype

The proposed research would benefit drivers around the globe who have to drive though unknown high risk areas. This would also benefit people living in war zones, and conflict areas. S_2N will enable drivers to select routes based on the time of the day, level of safety, travel time and many other parameters.

The paper is organized into five sections. Section 2 presents a study of the literature which incorporates a brief description of the Sat Nav solution and reports on the progress in the field. Section three reports on the parameters which will be used for calculating the route. Section 4 presents the architecture for the proposed S_2N framework. Section 5 contains the conclusion and future work.

2. Related Work

An extensive literature review was conducted to identify the state of the art solutions regarding the following:
1. Sat Nav device features specially those relating to safety
2. Crawling safety information from the Web
3. Security situation around the globe

2.1. Sat Nav Solutions

The purpose of a Sat Nav is to enable drivers to find their way on unfamiliar roads. There are two types of Sat Nav solutions available on the market. These are the in-car Sat Nav devices and the navigation apps for mobile phones. The in-car devices have a relatively powerful GPS sensor and are more reliable specially for traversing inner city roads. While the mobile phone apps are cheap and even free in some cases. In-car Sat Nav market is dominated by Garmin, TomTom each of which provide different features and extensive maps. In-car navigation systems are really effective in terms of finding the shortest route. As these systems update the map data on everyday basis. These also include the live traffic information feature for USA, EU and other developed nations. TomTom also uses a vast historic traffic data set which has over 9 trillion traffic data

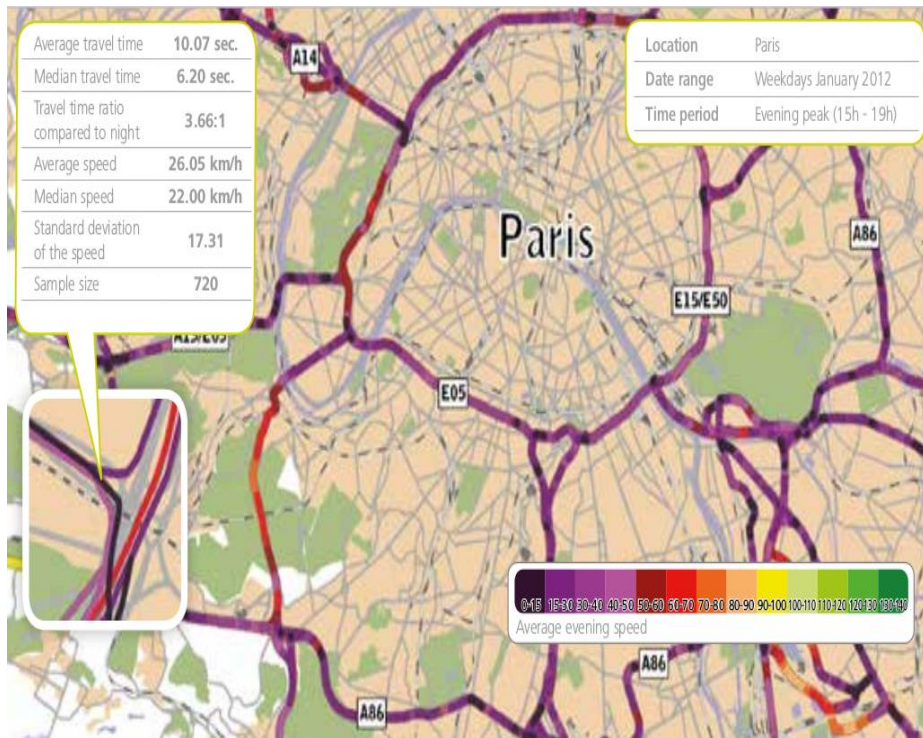points. This intern enables the Sat Nav to calculate the shortest route very accurately. [6,7,8]

Figure 1. Historic Data based Traffic Density Map for Paris [9]

The historic data enables the Sat Nav system to predict the amount of traffic on a road at the given time. Figure 1 shows traffic density map for Paris, the historic data set contains the vehicle speed and journey time records for different roads. The roads shown in dark purple were very congested as the average speed there was 10-15 km/h while those in orange and yellow were better offering speeds of upto 100 km/h. [9]

Figure 2. Global Coverage of TomTom [10]

Sat Nav providers have made a lot of progress in terms of calculating the shortest route unfortunately however the safety/security features have largely gone untouched. A key reason for this may be the countries where such providers are operating. Figure 2 shows regions where TomTom is active (gathers data). The data is gathered for 57 countries most of which rank highly in terms of safety and have very low crime rates. [10]

2.2. Crawling the Web for Security Threats On A Route

The Web is a great source of information and is being crawled every second for content, and usage statistics. The crawling process is performed by a number of private and public organizations. These include corporations who crawl the web for potential customers, it also include governments who crawl it for intelligence information. In the 21st century print media is struggling to survive as most of the news has moved online. This enables the user's to get up to date information regarding any event around the globe. The social media is also a major source of information where people share events occurring around them. Another source of information is the online forums and the blogging community. Such information can be utilized to identify the security situation in different parts of a city, which in turn would enable the user to make well informed decisions. A major challenge in using such information would be identifying the level of authenticity as on such forums anyone can write anything. [11]

2.3. Safety Situation

It is unfortunate that in this age of information people are still facing violence on a daily basis. Every year thousands of people around the globe are killed on roads as a result of violence.
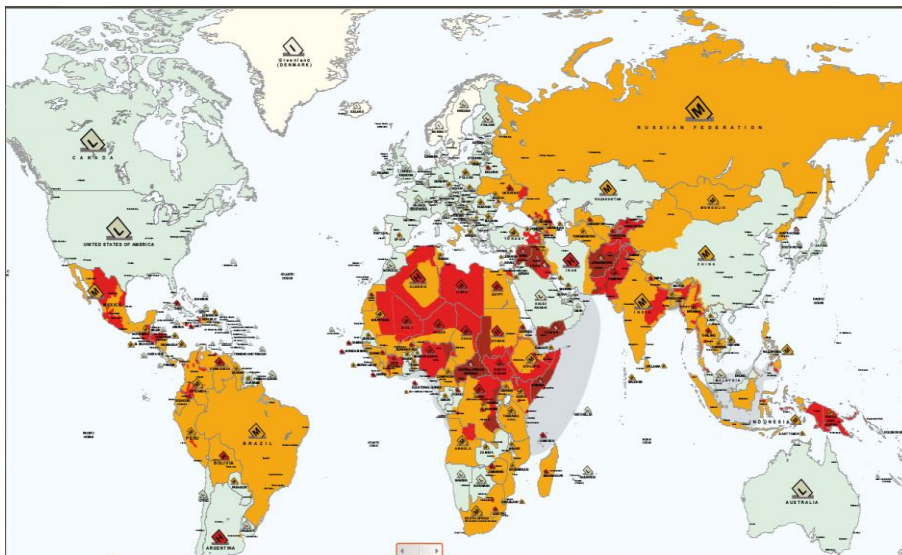

Figure 3. World Security State [12]

Figure 3 represents the security state around the globe. It is evident that countries from where most of the navigation data is gathered are really safe and marked with L for low risk. While most of the global population face at least medium levels of risk. People living high risk countries like (marked with red) always take security/safety as a consideration while traveling as they are aware of the risks surrounding them.

From the literature review it was evident that people living in high risk areas such

cannot rely on the current Sat Nav solutions for reaching their desired destinations. Therefore S$_2$N Framework is being proposed to identify routes which are not only shortest in terms of travel time and also safe enough to use [12].

3. S$_2$N Framework

The aim of S$_2$N is to help people in finding safer routes to travel. This involves identifying the parameters which affect the route selection. The next step is to gather and process information regarding the selected parameters. This information would be used by the S$_2$N in selecting the best route.

3.1. Parameters Affecting Route Selection

Several factors play a vital role in the ultimate selection of a route. As mentioned earlier the current systems for satellite navigation take into consideration a very small subset of the overall parameters that greatly influence our daily road selection criteria and preferences.

Whenever we travel on a known road we always take into consideration factors like traffic density during specific times. If a road has many office buildings, schools or colleges you may notice a sudden rise in traffic during particular time slots. Similarly traffic during weekends and public holidays follows a varied pattern just as a jam packed road in the morning may be completely deserted at night.

Street crime is a growing concern in many cities and factors such as types of crimes on a selected route, the frequency of the crime, the intensity of the crime (mugging, money or car snatching, kidnapping, murder *etc.*) and timings of major crimes or on particular roads are extremely important considerations that need to be included in an intelligent Sat Nav system. The following table provides a list of factors that need to be incorporated into the Sat Nav system.

Table 1. Parameters Affecting Route Selection

Data Category	Parameter
Historic Traffic Data	Traffic Density, Bottlenecks en route, Travel time during specific hours, Speed at specific times, frequency of accidents, road violations, lighting on the road, number of signals/traffic lights
Historic Crime Data	Types of crimes, level or intensity of crime, time of crimes
Policing	Check posts en route,
News and Social Media	Traffic jam, road congestion, VIP movement, current accidents, protests/demonstrations/strikes, roadwork, construction, weather conditions
Maps	Distance to destination, Size of the road (number of lanes), Inner city or highway, Landmarks on the road
Road Quality	Type of car, skill of the driver, time of day

3.2. Parameter Information Acquisition

Historic traffic data would be acquired by fitting GPS/GSM trackers on vehicle. As of now the research team have acquired four Tk103B trackers for gathering data. This would be gathered by developing a Web Application capable of receiving traffic data (travel time, speed) from the four vehicle at regular intervals. Another option would be to use a memory card to store the data in the tracker and process it at the end of each day. Historic crime data is provided in developed nations like UK where a person can type an address online and would get all the crime data for the given street. This however is not the case

for the developing nations, for this purpose a data repository would be created based on information from the Web. The information would be crawled using a customized Web Crawler, there are numerous APIs available for developing crawlers. We would use Java based Jsoup Api for crawling news, blog, social media information from the Web based sources. Google maps Api would be used for the map data. Other source of information like the CCTV can also provide vital traffic information.
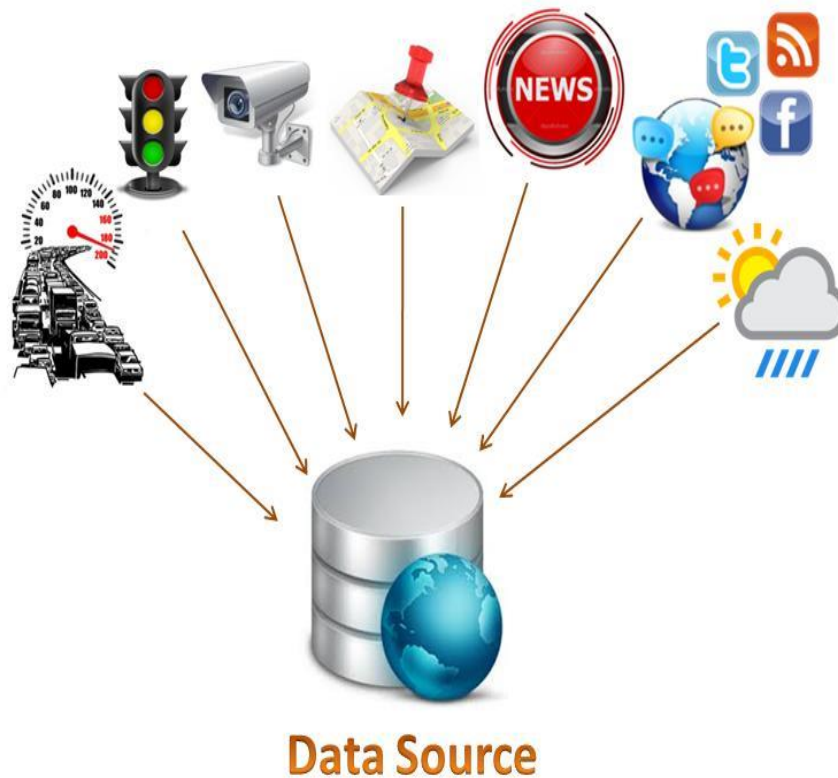

Figure 4. Information Acquisition through Multiple Sources

4. Design of S$_2$N Prototype

The data crawl techniques are exploited to get rating of the selected/chosen/preferred routes. To this aim, news articles related to the considered city and the preferred routes are given as an input to data crawl module. The data-crawl module processes the news articles for identifying the safest and shortest routes for the final selection. In particular, the module performs pre-processing steps such as language-dependent analysis to eliminate the stop-words and high frequency words. For example, *full stops, The,* and *To* words are eliminated by the help of Natural Language Toolkit (NTLK) stop word corpus [13]. Moreover, an algorithm named lemmatization that is based Wordnet [14] library is used exploited to transform the news article file into their corresponding lemma. For instance the word '*Evaluates*' is transformed into its corresponding lemma '*Evaluate*'. The processed document lemma is then resented into bag-of-word (BOW) [15] representation.
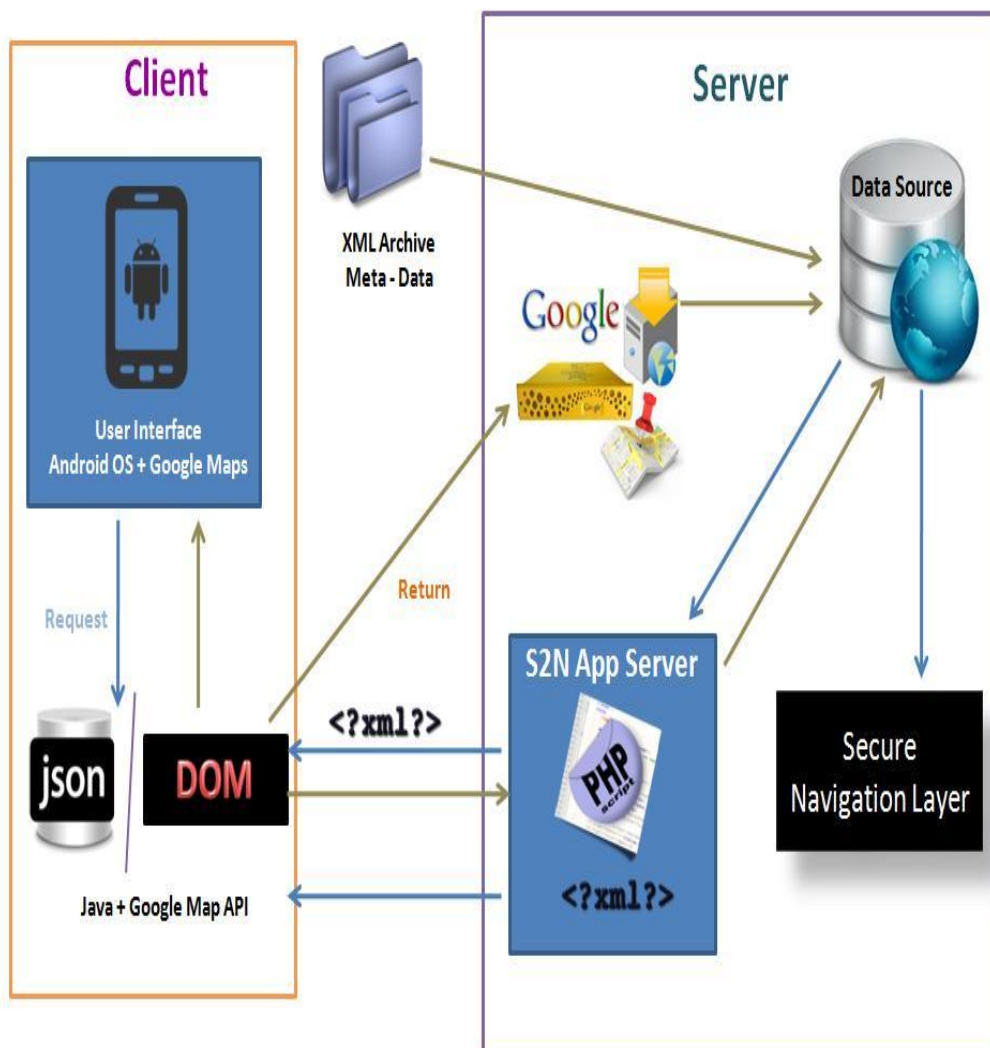
Figure 5. Design of S$_2$N Prototype

After pre-processing steps, the news articles are transformed into transactional database, which is a set of transactions (*i.e.,* sentences of the considered news articles). The selection of routes is investigated by analyzing the transaction using Wordnet library. The routes containing positive remarks in the news articles are ranked high and vice-versa. For example, if the transaction contains route name and positive remarks like *'good', 'fine', 'safe', 'not bad'* are labeled as high ranked routes. Likewise, transactions having route names along with negative remarks are ranked lower. Finally, an output file is generated for further processing and decision-making purposes. The output file comprises of the routes given by the users along with their calculated ranking. For example, the user provided 'Shahrah-e-Faisal' as preferred route along with news article of the Karachi city routes. The data-crawl module provides user with the out containing data such as 'Shahrah-e-Faisal – 80 Score'. The score identifies the rank of the route, the higher the rank, safe will be the route.

5. Conclusion & Future Work

The aim of this research is to enable people to travel safely and reducing the chances of street crime. To this end this paper has presented the S$_2$N framework along with a design

for the initial prototype. The paper also includes a list of parameters which affect the route selection process. Information sources for such parameters and mechanisms for extracting such information are also presented.

Future work for this research includes implementing the proposed S$_2$N prototype. Quantitative and qualitative evaluation of the S$_2$N prototype. Furthermore advancements could include live traffic updates through crowd sourcing. These would enable drivers to share traffic information and receive traffic alerts through text messages. In terms of data acquisition mechanisms for processing and incorporating CCTV information video would enhance the quality of S$_2$N.

References

[1]   J. Speakeand and S. Axon. "I Never Use 'Maps' Anymore: Engaging with Sat Nav Technologies and the Implications for Cartographic Literacy and Spatial Awareness", The Cartographic Journal, vol. 49, no. 4, **(2012)**, pp. 326-336.
[2]   N. B. Hounsell, "Review of urban traffic management and the impacts of new vehicle technologies", Intelligent Transport Systems, IET, vol. 3, no. 4, **(2009)**, pp. 419-428.
[3]   BBC Urdu News Desk, "Every other household in Karachi faced crime", DOA, http://www.bbc.co.uk/urdu/pakistan/2015/03/150302_karachi_crime_survey_bbc_sq, **(2016)**.
[4]   A. Bruns, "Gate watching: Collaborative online news production", vol. 26, **(2005)**.
[5]   N. Thurman, "Forums for citizen journalists? Adoption of user generated content initiatives by online news media", New Media & Society, vol. 10, no. 1, **(2008)**, pp. 139-157.
[6]   V.D. Aalst, M.P. Wil, "TomTom for business process management (TomTom4BPM)", Advanced Information Systems Engineering, **(2009)**.
[7]   D.J. Laverick, J.C. Burrell and G.L. Burrell, "Hand-held navigational device", U.S. Patent No. D365,032, **(1995)**.
[8]   G.J. Robert, "Emerging technologies: Mobile apps for language learning", Language Learning & Technology, vol. 15, no. 2, **(2011)**, pp. 2-11.
[9]   T. Tom, "Real time and historical traffic, TomTom delivers a unique proposition", http://www.tomtom.com/lib/doc/licensing/RTTHT.EN.pdf. DOA, **(2016)**.
[10] T. Tom, "Traffic Stats – custom travel times. Road traffic information for travel and location based decision making", http://www.tomtom.com/en_gb/licensing/products/traffic/historical-traffic/custom-travel-times/?WT.ac_id=ttlic_footer_ctt, DOA, **(2016)**.
[11] H. Kwak, "What is Twitter, a social network or a news media?", Proceedings of the 19th international conference on World wide web. ACM, **(2010)**.
[12] Control Risks, "RiskMap 2015", https://www.controlrisks.com/webcasts/studio/flipping-book/RiskMap-Report-2015/RiskMap-Report-2015.html, DOA, **(2016)**.
[13] E. Loper and S. Bird, "Nltk: the Natural Language Toolkit, in Proceedings of the ACL Workshop on Effective Tools and Methodologies for Teaching Natural Language Processing and Computational Linguistics", Association for Computational Linguistics, Philadelphia, **(2002)**, pp. 1–4.
[14] Wordnet, "Wordnet Lexical Database. <http://wordnet.princeton.edu>, **(2013)**.
[15] C.Y. Lin and E. Hovy, "Automatic evaluation of summaries using n-gram co-occurrence statistics, in Proceedings of the North American Chapter of the Association for Computational Linguistics on Human Language Technology", vol. 1, **(2003)**, pp. 71–78.