Visual Analytics Dashboard for Exogenous Risk Management and Logistical and Strategic Planning of Supply Chains for Smart Factories

Markus Streibl, Christian Edelsbrunner, Markus Frühwirth, Peter Göri, Richard Liebmann, Dominik Nehl, Stefan Weigl, Selver Softic

IT & Business Informatics, CAMPUS 02 University of Applied Sciences

Abstract

In this paper, which focuses on the exogenous risks, a prototype is developed, which presents the users a world map with the country-specific risk factors. These risk factors, which have a massive impact on the supply chain of a company, are based on live data sources from the Internet, in order to provide up-to-date risk assessments. The prototype allows to place and link the individual company sites or suppliers in the world map. The resulting supply chains can be analyzed based on the exogenous risk factors such as weather and natural catastrophes, as well as war situations and terrorist warnings. Through a detail view, as well as through the comparability of several supply chains, based on an aggregation of the risks, the prototype provides users with the vulnerability of the supply chain as a measure of the risk exposure of the company.

1 Introduction

Value chains, as well as linking these to value-added networks, should meet the increasing demands on the products in terms of quality, availability and price by the end customer. A global supplier and distribution network is much more vulnerable to factors that are endogenous and exogenous than a local company network. Above all, the exogenous risks, such as weather and natural catastrophes, war situations and terrorist warnings, but also fluctuations in the oil or dollar price, which are sometimes country-dependent, can have a massive impact on the stability of the network. Accordingly, the responsible employees must assess the current risks along the supply chains, and make a recommendation on which

Veröffentlicht durch die Gesellschaft für Informatik e. V. 2017 in
M. Burghardt, R. Wimmer, C. Wolff, C. Womser-Hacker (Hrsg.):
Mensch und Computer 2017 – Workshopband, 10.–13. September 2017, Regensburg.
 https://doi.org/10.18420/muc2017-ws04-0398

suppliers to choose. For this purpose, relevant data, and information from the Internet is researched. The probability of occurrence and the extent of damage is then determined based on the gathered data. These numbers combined with the experience of the employees ultimately lead to a risk factor for the respective supply chain in Smart Factories. This paper describes the prototype which supports the users based on connected live data sources from the Internet. The availability of relevant sources intends to enable an up-to-date risk assessment.

In presented smart supply chain risk management prototype the complex and diversified data is presented with the help of Visual Analytics. The overall goal is to gain knowledge to improve strategies in the supply chain planning of Smart Factories e.g. through optimized space saving plans that prevent stockpiling of unnecessary parts and strategically planning of stockpiling of those parts delivered by a certain endangered supply route.

2 Related Work

(Hotwagner 2008) defines the term "risk management" as a decision-making process that is based on incomplete information regarding future events and their negative effects such as damage or loss. Given that, the supply chain risk, which describes a damage and its occurrence for the entire supply chain, can be deduced. The overall risks of a supply chain must always be viewed and evaluated in a multi-layered manner. Every risk is assessed based on two parameters, the probability of occurrence and the intensity of the damage impact, which can be visualized in the form of a risk diagram.

The term "Visual Analytics" is defined as "the science of analytical reasoning facilitated by interactive visual interfaces" (Wong and Thomas 2004; Cook and Thomas 2005). It is considered as a combination of the fields of information visualization and scientific visualization. The difference of visualizing some information and visual analytics is the combination of visualization, human factors, and data analysis to make decisions and to improve the division of labor between human and machine (Keim et al. 2008).

In matters of data analysis, visual analytics furthermore profits from methodologies developed in the fields of data management and knowledge representation, knowledge discovery and statistical analytics. Visual analytics is not likely to become a separate field of study (Wong and Thomas 2004), but its influence will spread over the research areas it comprises.

According to Jüttner et al. (Jüttner et al. 2003) the concept of a supply chain risk management should distinguish four basic constructs: supply chain risk sources, risk consequences, risk drivers and risk mitigating strategies. Further they defined four basic constructs of the supply risk management to identify related critical aspects of a managerial concept: (1) Assessing the risk sources for the supply chain; (2) identifying the risk concept of the supply chain by defining the most relevant risk consequences (3) tracking the risk drivers in the supply chain strategy and (4) mitigating risks in the supply chain.

3 Methodology

To generate a meaningful dashboard, which is used for a risk analysis of supply chains, it is imperative to query relevant data in real-time and to make use of it. As part of a desktop research potential data sources were identified and their interface availability was evaluated (see Table 1).

Name	**Static information**	**Category**	**Chosen**
Risk Map 2017	http://riskmap.controlrisks.com	General	
WeltRisikoIndex 2016	http://weltrisikobericht.de	General	
World Bank	http://data.worldbank.org	Economic	**x**
	Live data		
Financial Data	https://www.live-rates.com	Financal	
Flightstats	https://developer.flightstats.com	Flightdata	
GDACS	http://portal.gdacs.org	Natural Hazard	
Global Terrorism Index	https://en.wikipedia.org/wiki/Global_Terrorism_Index	Security	**x**
Global Peace Index	https://en.wikipedia.org/wiki/Global_Peace_Index	Security	**x**
NOAA Incident News	https://incidentnews.noaa.gov	Natural Hazard	**x**
Oil Price Index	http://www.oil-price.net	Economic	
Realtime Data Streams	https://www.pubnub.com/developers/realtime-data-streams	General	
UN Data: Waste, Murder, Inflation	http://data.un.org	Business, Security, Economc	**x**
US Geological Survey Earthquake Data	https://earthquake.usgs.gov	Natural Hazards	**x**
Weather Alerts	https://alerts.weather.gov	Weather	
Wunderground	https://www.wunderground.com	Weather	

Table 1: List of potential and chosen data sources

All identified data sources were subsequently evaluated. The time horizon, the category of the risk, as well as the number of available data sets (regional or global) were determined and grated with numerical values from 1 to 5. Value 1 represents a very good data source and 5 an insufficient data source. The sources were chosen based on the assessment. Furthermore, it was aimed to create a good mix of different risk categories in order to cover a broad field of risks. For the visualization of the exogenous risks of the supply chain, the following data sources (see Table 1 column 'Chosen') were considered.

4 Implementation

The concept envisages visualizing the exogenous risks of a supply chain to provide the best possible support for decision-making. This is achieved by the representation of the supply chain on a world map and a comparison function between different supply chains. The mobile application, which supports current tablets and smartphones and enables location-specific and device-agnostic rapid risk analysis, was conceived as a cloud service. The risk management process[1] describes the necessary steps (Identification, Assessment, Control, and Monitoring) to make informed statements about a supply chain. The identified risks are assessed based on sound data, which is available in form of news, statistics, and various live online sources to the users. A reasonable assessment of the risk of a supply chain can only be obtained when the endogenous and exogenous risks are considered together. During the creation of the prototype, the endogenous risks were deliberately neglected and the focus was placed on the visualization of the exogenous risks. These were divided into four classes as described in the following paragraph.

The concept presented in this paper describes a frontend for the Visual Analytics Dashboard, via which the risk data for each supply chain can be analyzed. The backend provides appropriate functions to manage the master data (factories as well as supply chains) and to perform the risk analysis. In order to provide the risk data per location an asynchronous background job called the "Risk Data Collector" (see Fig. 1) uses existing online data sources. It provides the raw risk information, which is used for an automatic risk assessment. A supervised learning process with neural networks is envisioned to apply the automatic risk assessment. However, this requires vast amounts of experience data, which is currently not available (see Conclusion and Outlook). Therefore, a manual risk assessment based on the online risk data was applied. These manual assessments can be used as training data to implement the learning process. The automatic learning process has not yet been implemented within the scope of this prototype.

The sources described in detail in section 3 are characterized above all by a worldwide data availability and the reliability and authenticity of the institutions, which provide the sources.

[1] https://www.procurementjourney.scot/risk-management-process

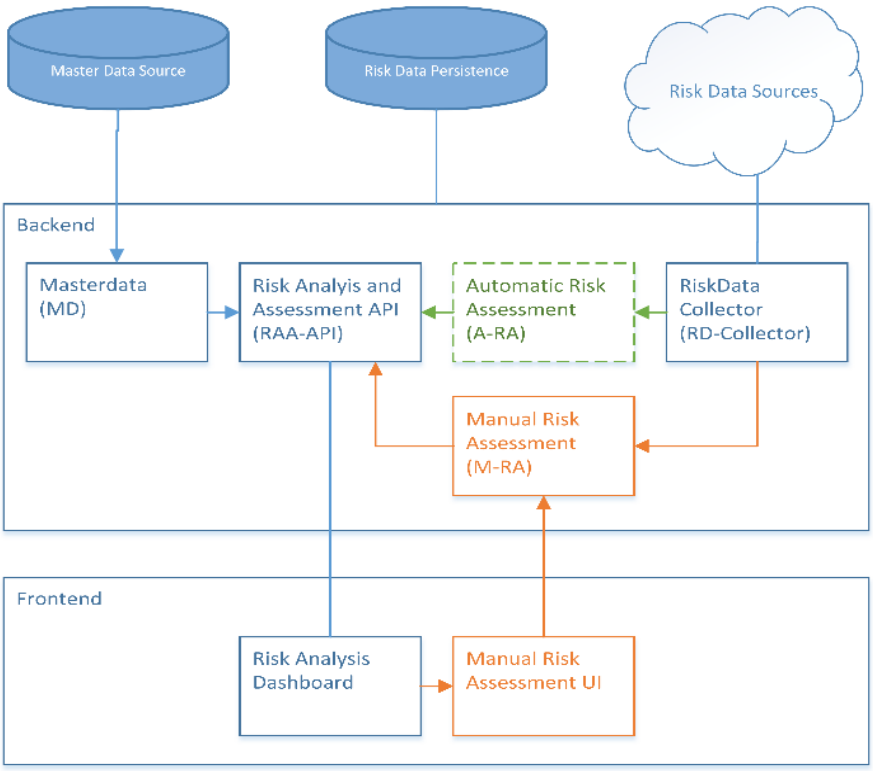

Figure 1: Software Architecture

The fact that risk-relevant data is often only available for individual regions or countries was included in the assessment of data sources.

The implementation of the prototype was based on a micro service architecture hosted on Microsoft Azure. The frameworks Asp.NET WebApi 2.0 and ASP.NET Entity Framework 6 were used. The functionality itself was implemented with the programming languages C # and T-SQL. The Risk Data Collector operates as a separate Webworker service, which accesses the online sources at appropriate time intervals. The time interval depends on the respective source and its rate of updates.

The frontend offers a RESTful web service, which is defined via a Swagger 2.0 compatible description. This allows an easy connection of additional clients. The risk data, the master data and the risk assessments are stored in a relational database system (Microsoft SQL Server). Alternatively, a business intelligence solution such as the SQL Server BI platform or other business intelligence solutions could be used for the backend.

The frontend of the prototype was implemented with the framework AngularJS. The graphical user interface strongly follows the material design developed by Google (see Fig. 2). The implemented risk map shows the supply chain and the various risks of each

individual site or factory. A supply chain can be selected in the world map, which displays either the risks in aggregated form by considering all suppliers or only the local risks per location. This depends on the definition in the master data. A detailed view is available for each location, showing all risks in a table and in the form of a risk diagram. This detail view provides functionality to edit the risk indicators (the assessment) based on the online data.

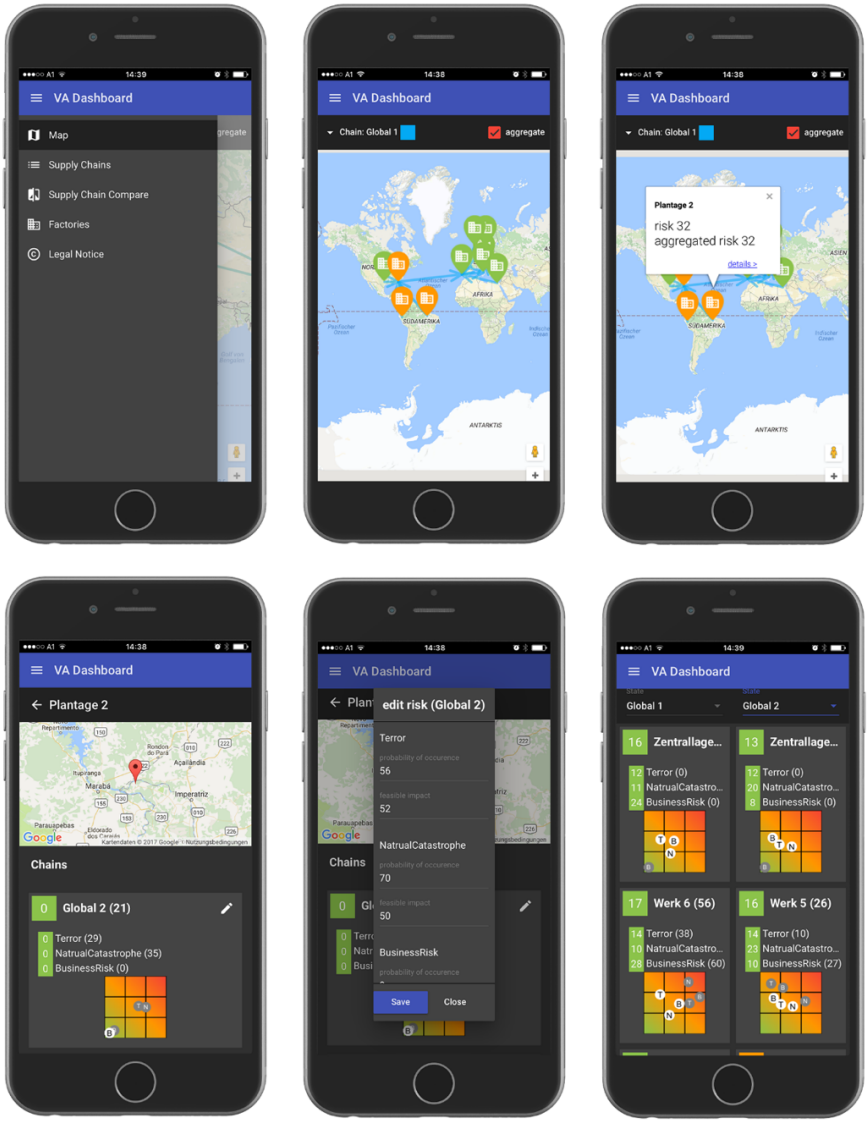

Figure 2: Visual Analytics Dashboard (World Maps and Supply-Chain View)

5 Preliminary Results

This approach focuses on the visual analysis of exogenous risks based on four predefined risks: natural disasters, financial risks, business risks and security risks, such as terrorism. The prototype was reviewed by experts and classified and accepted as a "proof of concept" solution. During the implementation, great attention was paid to the usability on mobile devices. The responsive implementation of the prototype enables users to identify and avoid the risk of potential supply chains anywhere on any device. The prototype also offers the ability to compare different supply chains regardless of their length. Both features combined allow decisions to be made within a few minutes. The comparison parameters in the prototype are currently limited to risks like possible terror attacks and natural catastrophes, as well as business risks, influenced by the dollar price and crude oil price.

6 Conclusions and Outlook

The risk factors for exogenous risks provided by the prototype offer a valuable complement to the company's internal risks. The combination of both represents a valuable decision-making aid in initiating the necessary measures to meet the quality, price and availability requirements and thus ensure customer satisfaction. A responsive web design implementation allows to use the tool independently of the location and device. The supply chains can currently consist of an infinite number of factories. These supply chains can be analyzed and compared based on individual exogenous risk factors such as terror, natural catastrophes and business risks. The comparison, which can be made based on risk factors for a particular factory or based on aggregated values for the entire supply chain, enables users to assess the potential risks and to select quickly and easily the appropriate supply chain. In future development stages, the current data, which comprises short-term events, will be supplemented with historical data to derive trends and to make predictions by applying data mining. As a result, the risk indicators will be automatically extracted from the live data using the mining model. To enable this, the live data is currently processed manually in the prototype to collect more training data which can subsequently be used for machine learning purposes. For example, machine learning could be used to predict potential interruptions in the supply chain based on observed indicators. Future versions of the platform will be enhanced with user management functionality, an individually customizable dashboard, as well as a simple creation and positioning of new supply chains in order to increase the user experience. The production-ready product will ultimately be hosted as a SaaS solution in a data center and therefore allow a quick rollout to customers.

7 References

Cook, Kristin A.; Thomas, James J. (2005): Illuminating the path. The research and development agenda for visual analytics. Pacific Northwest National Laboratory (PNNL), Richland, WA (US).

Hotwagner, Barbara (2008): Supply Chain Risk Management und dessen systemische Umsetzung im Unternehmen. In: *Supply Chain Risk Management*, S. 23.

Jüttner, Uta; Peck, Helen; Christopher, Martin (2003): Supply chain risk management. Outlining an agenda for future research. In: *Int. J. of Logistics Res. & Applications* 6 (4), P. 197–210.

Keim, Daniel; Andrienko, Gennady; Fekete, Jean-Daniel; Görg, Carsten; Kohlhammer, Jörn; Melançon, Guy (2008): Visual Analytics. Definition, Process, and Challenges. In: Andreas Kerren, John T. Stasko, Jean-Daniel Fekete and Chris North (Hg.): Information Visualization: Human-Centered Issues and Perspectives. Berlin, Heidelberg: Springer Berlin Heidelberg, P. 154–175. Online verfügbar unter http://dx.doi.org/10.1007/978-3-540-70956-5_7.

Wong, Pak Chung; Thomas, J. (2004): Visual Analytics. In: *IEEE Comput. Grap. Appl.* 24 (5), P. 20–21. DOI: 10.1109/MCG.2004.39.