Enabling Business Analytics in SMEs: The Trivi Open-source System

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Abstract. The purpose of this project is to propose an open-source system, called the Trivi system, for enabling business analytics in small and medium-sized enterprises (SMEs). The paper presents the key activities of the project development, including problem identification and motivation, objective definition, design and development, demonstration, and evaluation. The project's main outcomes are a knowledge development process, a set of use cases related to business analytics techniques in SMEs, and a general architecture for business analytics systems. Moreover, a four-level service architecture (data, information, analytics, and decision services) of the Trivi system is proposed, and a case study about the first validation for the cultural sector is presented.

1 Introduction

The domain of business analytics (BA) has improved significantly over the past few years, which helps business users to obtain better insights for creating innovative products and services, improving operational efficiency, and fostering customer relationships. However, the adoption of BA remains limited, particularly in small and medium-sized enterprises (SMEs) due to their barriers related to human and financial resources [1][2]. Furthermore, big data, which refers to the use of analytics techniques on big datasets for customer analysis, provides great opportunities for SMEs to make better business decisions but also poses challenges due to the complexity of processing large and heterogenous datasets [3].

SMEs are key players in the economy and the wider business ecosystem; therefore, enabling them to participate more actively in digital transformation is essential for boosting economic growth and delivering a more inclusive globalization. However, most SMEs find it challenging to overcome the obstacles related to business analytics [1].

To assist SMEs in promoting business intelligence and analytics from business data, especially big data, to gain competitive advantages, this project proposes an approach based on an open-source system, hereafter referred to as the **Trivi system** (inspired by the name of our city: Trois-Rivières) for elaborating a business analytics solution that is tailored to the specificities and limitations of SMEs.

As a result, the development process is divided into six major phases based on the design science methodology [4] that are as follows:

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1. *Problem identification and motivation:* assisting SMEs in promoting business analytics while considering their limitations;
2. *Objective definition:* proposing an open-source business analytics system for SMEs;
3. *Design and development:* producing the Trivi system;
4. *Demonstration:* experimenting with the system in the case of customer intelligence and implementing the first validation for the cultural sector based upon the Trivi system;
5. *Evaluation:* testing the first validation to ensure its functionalities; and
6. *Communication:* publishing results in academic and industrial communities.

The rest of the paper is organized as follows. Section 2 describes the problem identification and motivation. Section 3 continues with the objective definition, including the functional assessment and needs for the system. Section 4 deals with the design and development, which covers key components and the functional creation of the new system. Section 5 presents the Demonstration phase, which concerns the first validation of the Trivi system with a cultural organization. Finally, Section 7 ends the paper with discussions, contributions, and future work.

2 Problem identification and motivation

This section discusses the challenges faced by SMEs and then suggests how the Trivi system can overcome those challenges. In fact, the poor adoption of business analytics in SMEs is caused by a number of reasons as presented in Table 1 [1].

Table 1. The challenges faced by SMEs related to the adoption of business analytics.

Challenges	Description
Lack of data	This issue relates to the lack of data collection and/or transformation strategies for business analytics systems.
Limited analytics expertise	Due to their lack of analytics skills, management and staff may encounter considerable challenges while deploying new digital technology.
Shortage of data specialists	Finding, hiring, and retaining data specialists is difficult for SMEs due to a shortage of skilled professionals.
Financial obstacles	Financial limitations and onerous regulatory restrictions can add to the difficulties.
Absence of SME-tailored solutions	The specific needs of SMEs are not always taken into account by several analytics technologies.
A lack of business cases	One of the key success factors for the effective diffusion of innovation in SMEs is the availability of successful case studies and success stories.

In order to address the key challenges mentioned above, the Trivi system at first interoperates with popular data sources in SMEs such as data from enterprise systems, websites, and social networks [5]. Secondly, the system is designed based on different business situations so that users with limited expertise in business analytics can also use the system. Thirdly, the system is foreseen to be used in training business analytics at business schools to form data specialists. Fourthly, the proposed solution is an open-source system so that the financial obstacles will not be a real problem. Thus, since it is open-source, SMEs and service providers for SMEs can adapt the system to become SME-tailored solutions. Finally, the experimentation of the Trivi system with different SMEs can be published as business cases so that SMEs can inspire by successful stories.

3 Objective definition

The purpose of the study is to propose a Trivi open-source system for elaborating a business analytics solution, which is tailored to the specificities and limitations of SMEs. To develop business analytics in SMEs, the deliverables of the project include a knowledge development process, a set of use cases related to business analytics techniques, and a general architecture for business analytics systems.

Based on the service science perspective, the objectives of the project should cover multifaceted dimensions of science, management, and engineering in order to promote business analytics as a service [6]:

- The *management dimension* focuses on the knowledge development process that applies business intelligence to specific business cases.
- The *science dimension* involves the set of use cases that exploits business analytics to transform business data into business intelligence.
- The *engineering dimension* deals with a general architecture for a business analytics system that focuses on acquiring, integrating, and classifying data and knowledge from different sources.

4 Design and development

This section describes the development of this project using the Design science methodology, which is one of the most popular methodologies for developing and evaluating artifacts in information systems in general, and business analytics systems, in particular [4].

As an open-source method to assist SMEs in making better marketing decisions by utilizing business data, the general architecture of the Trivi system is depicted in Figure 1 [1]. The Trivi system is made up of three layers:

- A *backend layer* is built on top of the Django framework[1] to carry out system operations and provide services;
- A *frontend layer* is built on top of the ReactJS[2] framework to ensure interaction with end users (such as managers) and/or other applications (such as decision support systems, and recommendation systems); and
- A *cloud-based solution* is to speed up service provision.

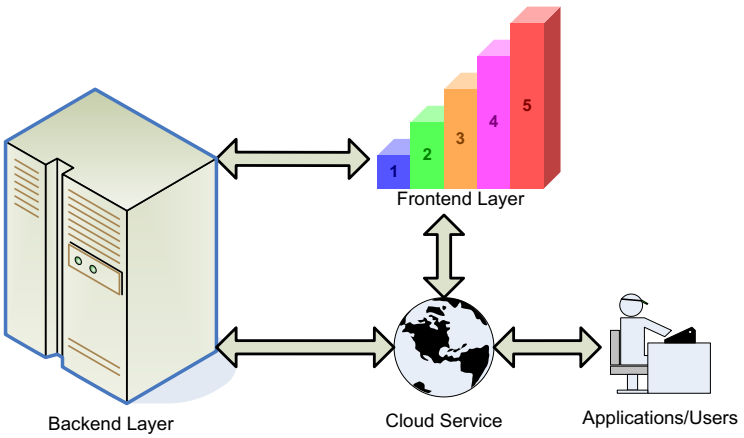

Fig. 1. The general architecture of the Trivi system.

[1] https://www.djangoproject.com/
[2] https://react.dev/

4.1 Backend layer

As presented in Figure 2, the *backend layer* is the cornerstone of the Trivi system, providing services at four levels of the knowledge development process, inspired by the DIKW hierarchy [7], including Data Services, Information Services, Analytics Services, and Decision Services [1]. Each service level can be employed by other levels or delivered directly to users or other applications through APIs. The paper also uses a running example about customer intelligence to demonstrate the real-world application of those services [2].

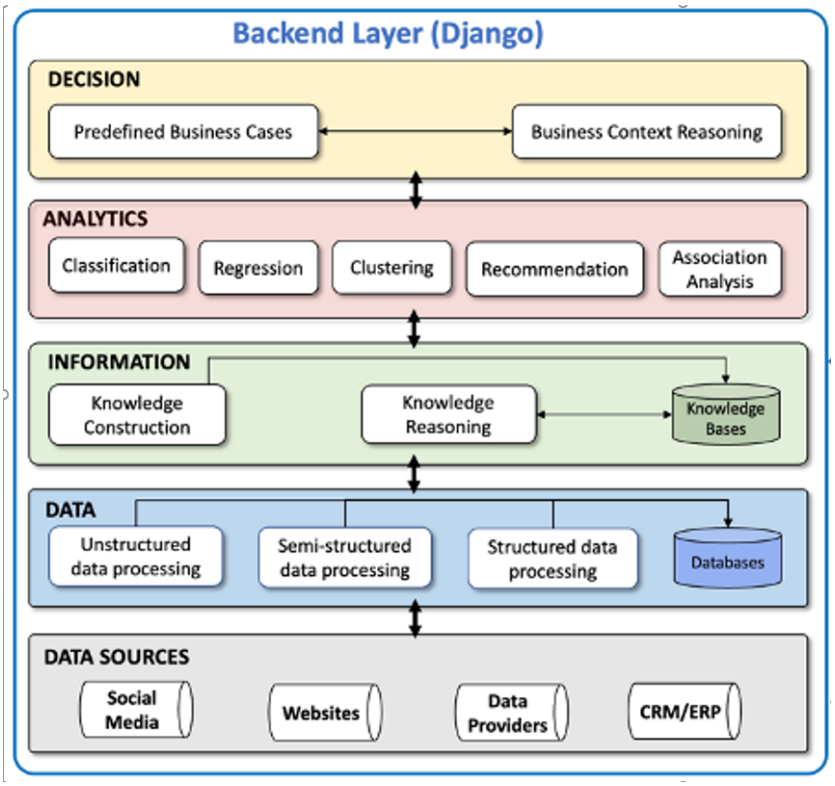

Fig. 2. The backend layer of the Trivi system.

Data services are concerned with the collection, processing, storage, and manipulation of business data from various data sources, such as social media, enterprise websites, third-party data providers, traditional enterprise databases (CRM/ERP), and inter-organizational information systems [8]. The processed data is then stored in databases that leverage various types of business data, for example, demographic customer data, psychographic customer data, and transactional data.

Information services are concerned with organizing business data in a suitable manner for analytics. *Knowledge construction* transforms data preprocessed in the data service level into knowledge bases by featuring different knowledge components: know-what, know-who, know-how, know-why, know-when, and know-where [1][2]. *Knowledge reasoning* then performs primitive queries on knowledge bases to retrieve useful information for the analytics service level, for example, obtaining interactions (know-how) of a particular customer (know-who) performed through mobiles (know-where).

Analytics services serve business insight generation that can be classified based on their tasks, for example, determining whether a customer belongs to a profitable or non-profitable

group (*classification*); estimating customer values (*regression*); identifying customer segments (*clustering*); recommending appropriate products to a specified user (*recommendation*); or finding hidden relationships between products (*association analysis*) [5, 6]. Those analytics tasks can be accomplished through the use of data mining algorithms on information obtained from the information service level, for example, K-nearest neighbors used for classification tasks; content-based filtering adopted for recommendation tasks [9].

Decision services provide systems functionalities on top of the analytics service level to achieve *predefined business cases* (e.g., identifying the most profitable products, and recommending potential products based on content-filtering). These *predefined business cases* assist managers in decision-making [2][9]. For example, discovering product associations can aid in cross-selling, and identifying customer segments can aid in developing marketing campaigns for a target group.

4.2 Frontend layer

The *Frontend layer* provides API (Application Programming Interface) or GUI (Graphical User Interface) for accessing services (Figure 3).

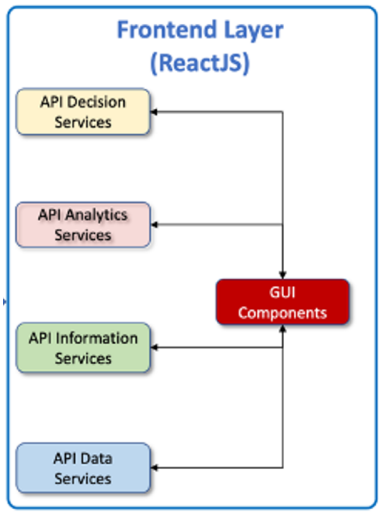

Fig. 3. The frontend architecture of the Trivi system.

For the Trivi system's frontend layer, the ReactJS framework, a free and open-source JavaScript toolkit, was chosen for creating reusable user interface components.

The *API services* are in charge of sending requests to the backend layer, receiving results, and distributing the results to other applications (e.g., chatbots), according to the four levels of services (data, information, analytics, and decision services).

The *GUI components* deal with displaying business insights through interactive actionable dashboards, tables, or charts [1][10]. The API services are typically invoked from other applications, whereas the GUI components are typically used to serve end users such as managers. The GUIs can be customized to meet end users' requirements.

4.3 Cloud Service

The *Cloud service,* which refers to infrastructure, platforms, and resources (hardware or software) offered by third-party providers such as Amazon Web Service (AWS)[3], Microsoft

[3] https://aws.amazon.com/

Azure[4], or Google Cloud[5] through the Internet, is adopted to facilitate service delivery across various enterprises. For the Trivi framework, AWS EC2 Cloud Service was selected as the cloud service provider due to its benefits such as flexibility, scalability, portability, simplified management and configuration, and high levels of security protection.

5 Demonstration and evaluation

In terms of validation, the Trivi system is used to elaborate a business analytics system to foster the customer relationship for a cultural organization in Quebec[6], Canada [10].

5.1 Demonstration

On the *backend layer*, customer data from the organization's website and Google Analytics is transformed into the system's databases through data mapping operations at the data service level, which are further structured at the information service level. In the next step, content-based recommendation algorithms are used at the analytics service level to propose similar cultural events and/or generate statistical data (e.g., top landing pages, customer journey) in the decision service level (Figure 4).

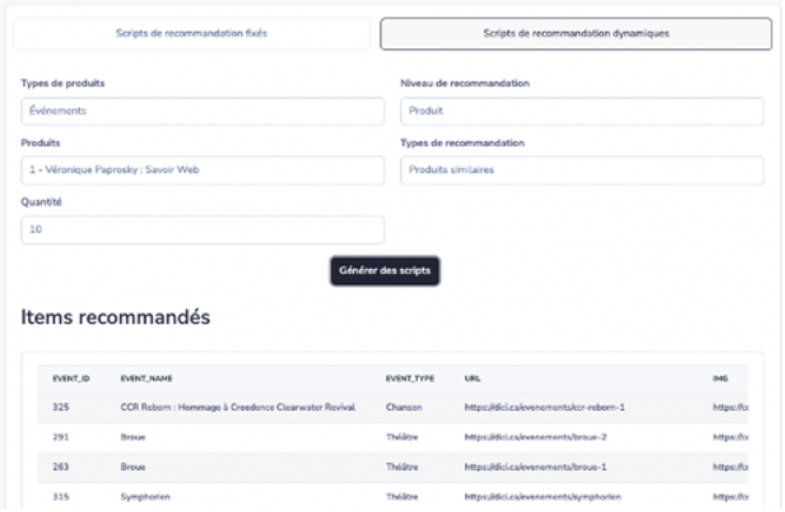

Fig. 4. Recommended potential products.

Dashboards, tables, and charts are used to visualize analytics results *on the frontend layer*. A set of recommendation APIs is also provided for use on the organization's website. The system is hosted on AWS EC2[7] and IONOS[8] *cloud services* for service delivery. Examples of GUI interfaces are shown in Figure 4 and Figure 5.

[4] https://azure.microsoft.com/
[5] https://cloud.google.com/
[6] Quebec is the only province in Canada to have French as its only official language. Consequently, the interface of the Trivi system for this experimentation is in French language.
[7] https://aws.amazon.com
[8] https://www.ionos.com

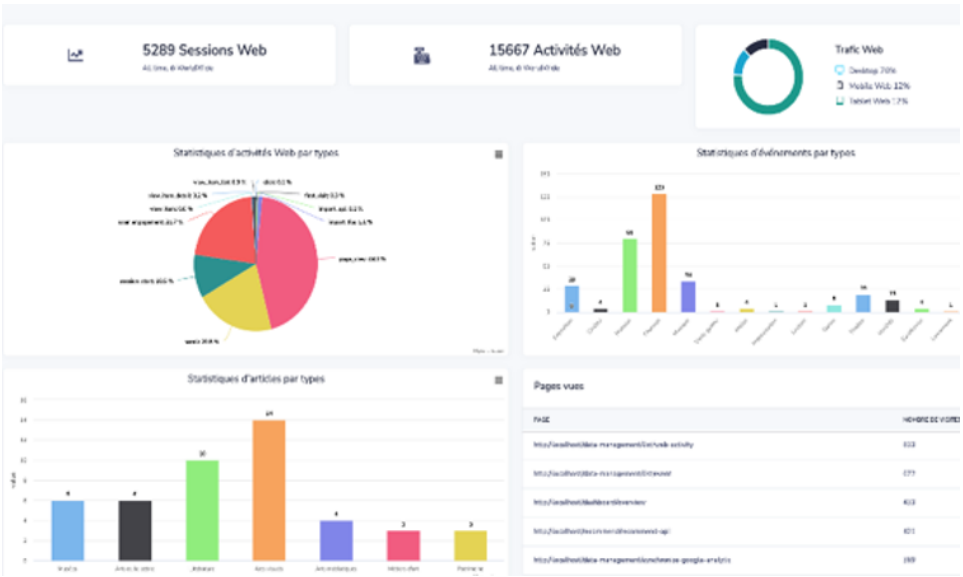

Fig. 5. Customer interaction insights.

5.2 Validation and experimentation

Unit, integration, and system testing are also carried out to ensure that the system is fully functional, well integrated, and meets the requirements.

The lesson learnt from this experimentation is that, the framework can be used to support four types of customer intelligence: *product/service innovation* (discovering product properties for product reporting or recommendation); *customer segmentation and profiling* (exploring customer profile/history for grouping customers); *customer experience* (concerning with customer interaction analytics); and *customer lifetime value* (dealing with customer value calculation) [9]. The goal of *business context reasoning* is to identify manager profiles or roles within an organization and then propose appropriate business cases. For example, when a marketing manager interacts with the systems, the appropriate business cases (product/service innovation) are served.

6 Discussion

This section discusses about the potential contributions of the project. Firstly, regarding originality, importance, and contribution to the advancement of knowledge, the application will highlight the importance of the proposed approach in considering the urgent need of SMEs related to the use of business analytics, which provides a wide range of opportunities for determining the needs of clients and partners, and for identifying the overall characteristics of national and local markets [11]. However, the adoption of business analytics by SMEs is still especially limited.

Secondly, the relevance of the theoretical framework or approach, the service science approach will be highlighted thoroughly and the evolution of service science in the big data era will be explored [12]. In particular, the three dimensions of service science such as engineering, science, and management will be used to demonstrate the completeness of the approach.

Thirdly, the relevance of methodologies or approaches, the design science research method will be explained. Moreover, the components of the Trivi system are presented comprehensively based on design science artifacts.

Finally, concerning societal benefits, startup founders, entrepreneurs, business managers, and students in business schools will be direct beneficiaries of the project. The project proposes an approach so that SMEs can overcome the challenges related to financial and human resources to leverage business value creation. Therefore, the project would promote the sustainable development of SMEs in the local region. Moreover, the approach will help business managers to perform business analytics to transform business data into business intelligence, which is critical expertise in the big data era. Besides, the knowledge development process and the Trivi system will be integrated into specific courses to teach digital marketing and business analytics in business schools.

7 Conclusion

This section summarizes the project and highlights its future works. The project proposes an open-source system for elaborating a business analytics solution with a consideration of SMEs' particularities and barriers. The purpose of the proposed approach is to accompany SMEs, step by step, to implement their own business analytics solution based on business situations. Consequently, the study has potential implications in different reflections of business analytics systems to enable data-oriented applications in business as well as intelligent systems in other domains in the future.

For the time being, the Trivi system will be enhanced to support large-scale business intelligence and analytics across multiple domains, such as assisting exporting firms within the context of internationalization or developing other business analytics systems for e-commerce companies. Another Trivi prototype is currently being developed to support smart interfaces for customer intelligence systems. The prototype can assist business users such as managers in gaining business insights from customer data to make better decisions. The Trivi system is expected to be available to the general public as an open-source system within the coming years.

In the future, the Trivi system will be extended to perform as a big data-driven knowledge management system with the focus on the transformation of different big data sources into valuable information and insights [13].

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