# Chapter 21
# A Generic Spatial OLAP Model for Evaluating Natural Hazards in a Volunteered Geographic Information Context

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## ABSTRACT

*Spatial data warehouses (SDW) and spatial OLAP (SOLAP) systems are well-known business intelligence technologies that aim to support a multidimensional and online analysis for a large volume of geo-referenced datasets. SOLAP systems are already used in the context of natural hazards for analyzing sensor data and experts' measurements. Recently, new data gathering tools coined as volunteered geographic information systems (VGI) have been adopted especially by non-expert users. Hence, (spatial) application development is facing a new challenge, which is the integration of expert-oriented data with citizen-provided data. In this paper, we propose a new generic spatio-multidimensional model based on the question/answer risk evaluation model that allows the integration of VGI data with classical SDW and SOLAP systems for the online analysis of natural hazards monitored by volunteers.*

## 1. INTRODUCTION

Due to the availability of multiple and diverse spatial data collection technologies such as sensor networks and satellites, organizations are facing the problem of dealing with a deluge of heterogeneous geo-referenced data. To exploit the analysis capabilities carried out by these data, GeoBusiness Intelligence (GeoBI) systems, among which are the spatial Data Warehouses (SDW) and the spatial OLAP

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(SOLAP), have been developed. The SDW and SOLAP systems are widely recognized as effective tools for the multidimensional and multi-scale analysis of large geo-referenced datasets (Bimonte 2010). SOLAP and SDW systems have been successfully deployed in several different domains such as health, agriculture (Nilakanta et al., 2008) and marketing. In classical SOLAP applications, data come from externally well-known on-line transaction processing (OLTP) systems, which allow the feeding of SDW factual data with numerically accurate values (Kimball, 1996).

However with the advent of new platforms such as web mapping and wiki tools, a new category of users known as volunteers (who are usually – thematic and information technology-unskilled users) is creating geographic data known as volunteered geographic information (VGI). VGI is defined as "*the harnessing of tools to create, assemble, and disseminate geographic data provided voluntarily by individuals*" (Goodchild, 2007). VGI systems have already proved useful for applications where up-to-date participatory data and knowledge are necessary in the decision-making process (Roche et al., 2011). Among those applications, the prevention and the management of natural hazard risks play a crucial role because natural risks may have enormous social and environmental impacts and may sometimes lead to important economic and human losses. Natural hazards are characterized as "*those elements of the physical environment, harmful to man and caused by forces extraneous to him*" (Burton et al, 1978). In other terms, a natural hazard can be considered as a disaster or an acute event that causes significant damage.

Both SOLAP and VGI systems have already been used for natural hazard monitoring and evaluation but from two different analysis perspectives. The SOLAP systems have been used for aggregation-based queries of precise, detailed and historical hazards evaluation indicators (Iris et al., 2006) (e.g., pesticides concentration), while VGI systems have been employed for exploring recent datasets with predefined queries.

The aim of the work presented in this paper is to extend the hazard evaluation functionalities provided by the SOLAP tools for integrating VGI data to leverage the scalability, security, cartographic and tabular visualization interactivity, and the good aggregation-based query performance features offered by the SDW and SOLAP systems when analyzing VGI data. To fulfill this aim, we propose a generic data model to represent a natural hazard evaluation in the VGI context. This model is based on the *question/answer* paradigm that fits with VGI users' profiles. Moreover, our model takes into account users credibility that characterizes VGI (Flanagin and Metzger, 2008). We implement our approach in a relational SOLAP architecture.

The paper is structured as follows: Section 2 introduces the SOLAP and VGI concepts, and Section 3 presents an overview of the existing work about SOLAP and VGI risks managing. Section 4 introduces our simulated case study and our spatio-multidimensional model. Section 5 presents the implementation and an analysis of the natural hazards evaluation in the VGI context using SOLAP systems. A discussion is presented in Section 6. Finally, Section 7 concludes the paper.

## 2. BACKGROUND

Volunteered geographic information (VGI) (Goodchild, 2007) represents a personal contribution of people in collectively creating a geospatial information resource. Citizens can be considered as simple sensors or collaborative citizens. Collaborative citizens report the problems by means of a geographical information resource and suggest the possible solutions (Haklay, 2010; Murgante, 2013). Within a VGI web context, "*a resource could be a geo-tagged photo, a collection of photos like Flickr, or a data validation*