IMPROVING FAULT DETECTION OF TRANSMISSION LINE WITH BIG DATA

A. Perçuku, D. Minkovska, L. Stoyanova

Abstract: *The capability to prevent faults in different devices is most important nowadays for normal operation and reliability of power transmission system. In industry, widespread rates and scales of data are being generated fast and from multiple sources. Gathering and analysis of those data offer a significant opportunity to enhance fault detection. This paper presents an improvement in fault detection of high voltage transmission line by using Big Data. As a case study is used 110 kV transmission line SS Prizreni2 - SS Rahoveci, part of Kosovo power transmission system.*

Keywords: fault detection, power transmission line, Big Data.

1. Introduction

The new digital technology in industry, which is known as Industry 4.0, and emerging Big Data, make possible gathering and analyzing data from various devices and sources, enabling faster, flexible and efficient way to increase quality services and reduce costs. This speed up innovations, improvements in productivity, cost efficiency and business performance. As devices and machines becoming smarter, the production will be enriched and the tasks will be simplest. Thanks to sensors and connectivity, the products will be improved by services like is prediction and they will be transformed also.

The ability to detect and diagnose the fault early on high voltage transmission line, as an important component, help on normal functioning and operation of power system. Detection, classification and location identified of a fault in transmission line are a challenge.

The aim of this paper is to propose a method by using Big Data to improve fault detection on power transmission line. The data analyses in this model is applied to large amounts of data set in order to improve fault detection, minimize loss and assure operability of power system.

As a case study is used high voltage transmission line 110 kV SS Prizreni2 - SS Rahoveci, part of Kosovo power transmission system. Actually this transmission line is operated in radial operation.

2. The fault detection of transmission line

Power transmission line is one of the main components on electric power system, and interconnects the power plants and loads and form an electrical network [1]. When a fault occurs on a transmission line, it is important to detect it and to find location in order to restore the power system as soon as possible and minimize possible interruptions. The ability to detect and diagnose the fault early, help on normal functioning and operation of power system. Detection, classification and location identified of a fault in transmission line are a challenge.

A fault on power system is an abnormal condition that involves an electrical failure of power system equipment operating at one of the primary voltages within the system. In transmission line the short circuit faults can occur between phases, or between phases and earth, or both. The types of faults can be one phase to earth, phase to phase, two phases to earth, three phases clear of earth and three phases to earth [2]. More methods have been developed to detect the faults; in this research paper is used Big Data technologies to improve fault detection.

3. Big Data, OrientDB NoSQL data store

Power electrical systems are very complex and have a lot of requirements. The advances on information technology and emerging of Big Data can improve the reliability of the system,

increase efficiency and decrease the costs. In general, Big Data is used for collection and analyzing large amounts of data and documents which are complex.

Big Data is a term applied to data sets whose size or type is beyond the ability of traditional relational databases to capture, manage and process them with low latency. Big data analytics is the use of advanced analytical techniques against very large, and diverse data sets that include structured, semi-structured and unstructured data, coming from different sources. To describe better Big Data, there are using 5 Vs [3], see Fig.1:

- Volume: refers to the vast amounts of data
- Velocity: refers to the speed at which new data is generated and the speed at which data moves around
- Variety: refers to the different types of data we can now use
- Veracity: refers to the trustworthiness of the data
- Value: refers to the ability turn our data into value

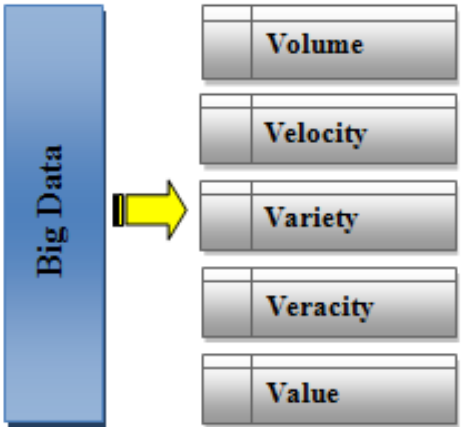

Fig.1 Big Data characteristics

Fig.2. The factors underling Big Data movement [4]

Big Data movement stems from the availability of data, high power computer technology, and analytics to handle data characterized by Vs [4], see Fig.2. The potential benefit from using Big Data and its challenge differ from study area. Big Data in industry facilitates process monitoring, and by uses them we can detect faults, diagnose them and predict future.

As a Big Data NoSQL data store in our study is used OrientDB. The OrientDB engine supports Graph, Document, Key/Value, and Object models, so we can use OrientDB as a replacement for product in any of these categories. The comparisons between OrientDB graph model vs relational model are: class (extends V for Vertex and E for edges) as table, vertex as row, vertex and edge property as column, edge as relationship [5]. In our case study the OrientDB has been used as Graph database.

The paper is conducted by reviewing more research papers. Golzer at al. [6] provided a category scheme for data processing requirements of Industry 4.0; this scheme can be used to match requirements and capabilities of solution-components to get new insights of necessary application. Perçuku et al. [7] proposed a model for collecting and storing large amounts of data, using Neo4j graph technology, for prediction more efficiently the maintenance of power transformer equipment. Xu et al. [8] studied fault diagnosis, divided into knowledge-drive, data-driven, and value-driven diagnosis based on different factors; a novel diagnostic idea called the DEKG (Device Electrocardiogram) is introduced witch transforms a diagnostic strategy. Reis et al. [9] provided a critical outlook of the evolution of Industrial Process Monitoring (IPM) since its appearance as an industrial activity. Wang et al. [10] established a fault data collection model by taking advantages of the high efficiency and stability of Big Data on data collection with the purpose to provide fast, accurate and unified data for upper layer fault diagnosis program.

Severson et al. [11] provided an overview of process monitoring methods and introduces the major challenges facing the next generation, and supported for the use of hybrid methods to address these challenges.

4. Case study

The large amount of data that can be captured from sensors can uncover much useful information, as identifying and detection a fault. In this research paper OrientDB graph NoSQL data store is used to store large data and as analytical tool for fault detection in high voltage transmission line.

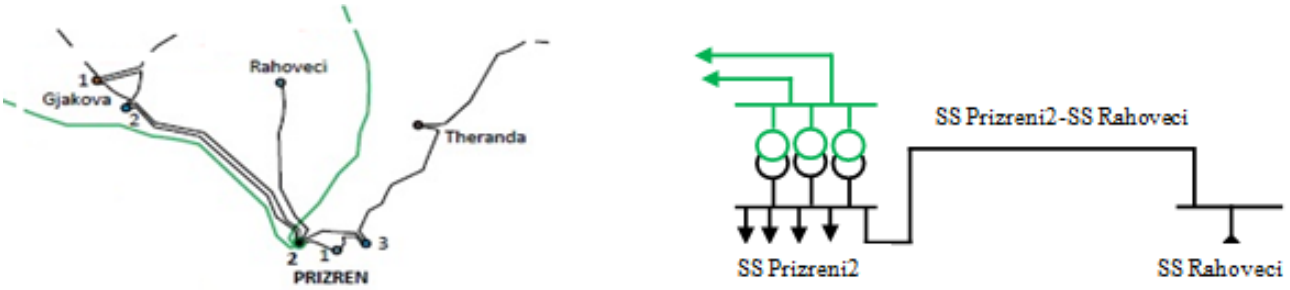

Fig.3. a. South part of Kosovo transmission system **b. Single line diagram of SS Rahoveci**

As a case has been studied the high voltage transmission line 110 kV (kilo voltage) between substation (SS) Prizreni2 and SS Rahoveci, see Fig.3 a and b.

From Fig.3 can be seen that actually SS Rahoveci has not redundant overhead transmission line, it means this substation has only one possible alternative way to receive electricity (it is in radial operation), and early detection of any fault on this line is most important to avoid possible interruptions.

The necessary OrientDB types of data model like class, vertexes, edges and their properties are used to model our case study such as SS Rahoveci, line SS Prizreni2-SS Rahoveci, weather_data, using these statements:

orientdb> CREATE CLASS <class>

orientdb> CREATE VERTEX [<class>] [SET <field> = <expression>[,]*]

orientdb> CREATE EDGE <class> FROM <rid>|(<query>)|[<rid>]* TO <rid>|(<query>)|[<rid>]*

orientdb> CREATE PROPERTY <class-name>.<property-name> <property-type>[<linked-type>][<linked-class>]

The technical parameters on transmission line and substation (SS) Rahoveci that are included as properties are: system frequency (Hz), voltages on three phases (kV), active power (MW) and reactive power (MVAr) on three phases, and current (A) on three phases. As weather parameters are included: temperature (^{0}C), humidity (%), wind speed (m/s), and pressure (bar). Voltages, active and reactive power, and current will be collected every min, and weather conditions every 15 min. All these technical parameter’s data will be inserted into OrientDB in very short period of time.

H	12:48	12:49	12:50	12:51	12:52	12:53	12:54	12:55	12:56	12:57	12:58	12:59	13:00	13:01	13:02	13:03	13:04	13:05	13:06	13:07	13:08	13:09	13:10	13:11	13:12	13:13	13:14	13:15	13:16	13:17	13:18	13:19	13:20	13:21	13:22	13:23	13:24	13:25	13:26	13:27	13:28
P (MW)	22,680	24,255	24,255	22,680	22,995	27,090	22,680	22,995	25,515	22,995	22,680	22,680	22,680	22,680	13,545	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,835	1,575	4,410	7,560	7,245	12,600	26,775	23,940	24,570	21,735
Q (MVAr)	7,875	9,135	10,710	9,450	10,710	9,450	10,710	7,875	10,710	10,710	7,875	9,450	10,710	9,135	4,095	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,260	1,575	2,835	1,575	1,575	4,410	6,300	9,450	8,190	8,190

Fig.4 The data of P(MW) and Q(MVAr) between 12:48 and 13:28 (08/09/2018)

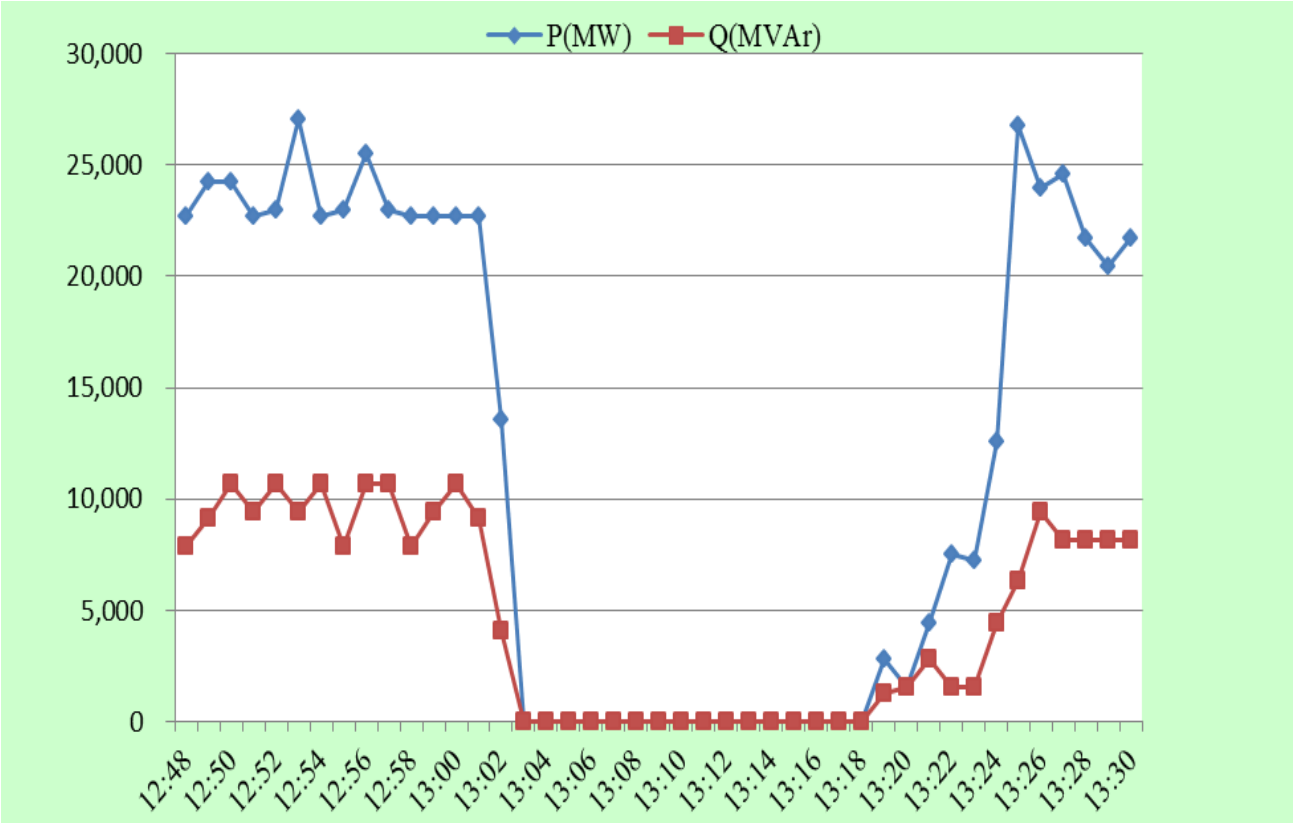

Fig.5 The P and Q during fault 08/09/18

Tab.1. Weather data in SS Prizreni2

Hour	T (^{0}C)	H (%)	WS (m/s)	P (bar)
12:15	27.9	33.9	0.2	1012
12:30	28.4	34.2	0.4	1013
12:45	28.5	34.1	0.1	1011
13:00	28.3	34.8	0.3	1014
13:15	28.9	35.1	0.5	1013

After every insertion of data, a query will be done regularly, and if there is a difference on values between phases on any parameter’s data than the query in OrientDB will identify that, and by this a fault will be detected.

This model is analyzed and tested by using archiving data. The archiving data for 2018 year have been putted in OrientDB database in very short period of time, and a fault that happened on transmission line SS Prizreni2-SS Rahoveci is analyzed. The data used are real data. The fault has happened on 08/09/2018 at 13:03. In Fig.4 have shown the data archived for one phase on transmission line SS Prizreni2-SS Rahoveci during the fault, and in Fig.5 has shown the chart from both P (MW) and Q (MVAr). The weather data in this region for the time between 12:00 and 13:15 are shown in Table 1. From analyses can be seen, how active power P (MW) and reactive power Q (MVAr) values have changed before the fault.

By using this model developed by OrientDB NoSQL data store, for collecting, storing and analyzing those technical parameters data in very short time, for three phases of transmission line is improved the fault detecting.

5. Conclusions

Power electrical systems are very complex and have a lot of requirements. The advances on information technology and emerging of Big Data can improve the reliability of the system, increase efficiency and decrease the costs. Detection, classification and identify location of a fault in transmission line as an important component on power system are a challenge.

The aim of this paper is to propose a method by using OrientDB as Big Data NoSQL store to improve fault detection on power transmission line. The data analyses in this model are applied to large amounts of data set. This proposed method has two stages:

a). In the first stage, the large amounts of data for all relevant technical parameters for three phases, are collected and stored in OrientDB NoSQL store, in very short period of time – every minute

b). In the second stage, the regular query clause is done on these data for three transmission line phases, to check and compare them and identify faults

As a future works, is the ability to make diagnostics of faults by using the developed model.

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ПОДОБРЯВАНЕ ОПРЕДЕЛЯНЕТО НА НЕИЗПРАВНОСТИ ПО ТРАНСМИСИОННАТА ЛИНИЯ С ГОЛЕМИ ДАННИ

А. Перцуку, Д. Минковска, Л. Стоянова

Резюме: *Способността за предотвратяване на повреди в различни устройства е важна в днешно време за нормалната експлоатация и надеждността на електропреносната система. В промишлеността се генерират бързо широко разпространени данни от множество източници. Събирането и анализирането на тези данни предлага значителна възможност за подобряване откриването на повреди. Тази статия представя подобрение в откриването на неизправности на високоволтовите предавателни линии с помощта на големите по обем данни (Big Data). Като казус се използва 110 kV електропровод СС Призрени2 - СС Раховец, част от косовската електропреносна система.*

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