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A Bayesian Belief Approach for Business Services in IoT

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Abstract: The Internet of Things is evolving as the next technology mega-trend, with a positive impact across the various fields like medicine, education, transportation and business. Challenges include capture, integration, storage and retrieval, security and privacy. Recent research work is diversified but storage, retrieval and the services provided for the data collected are key issues of concern. The data collected are large or complex that traditional data processing applications are not sufficient. Traditional data management and models will play also play a role, but these traditional systems have to handle large volumes of raw data from sensors that may be real time data or intermediate data. A shift from traditional database to Big Data management is needed. To provide services with stored data, data mining techniques are widely used. The data collected from different sources may be dependent or independent. There is a need to analyze data dependency among variables. A literature survey of Internet of Things (IoT) and a model is proposed for IoT data mining system in the market sector.

Keyword: IoT, Data mining, Business Models, Bayesian Belief Network.

1. INTRODUCTION

The Internet of Things (IoT) [1] is the web of physical devices and different things which are implanted with hardware, sensors, and system network that empowers these items to accumulate data. It permits devices to be controlled remotely over the current system association, making chances for more straightforward consolidation between the physical world and PC based framework, and bringing about better effectiveness, precision and monetary advantage. At the point when IoT is enhanced with sensors and actuators, the innovation turns into an instance of the broader class of digital physical frameworks. By connecting to the Internet billions of ordinary gadgets, the IoT unites the physical and online web, opening up a large number of ways for organizations, governments and buyers.

IoT has opened up new business opportunities and transform business in a new direction [60]. The enormous data produced by the Internet of Things (IoT) are considered of high business quality, and data mining calculations can be connected to IoT to remove concealed data from information. The data collected from sensors can be dependent and for reasoning the uncertainty in data a classification technique, Bayesian Belief Network can be used. A belief network is a directed model of conditional dependence among a set of random variables and

is used for reasoning under uncertainty. To identify hidden and missing values can also be achieved by belief network.

The contribution of this paper includes three main parts: The first contains the literature survey on IoT in various domains, business domain in specific and data mining services in IoT. The second part discusses the issues and challenges of IoT in business and business models. Third, a data mining system is proposed for Business IoT.

2. THEORETICAL BACKGROUND

IoT can be defined as a network of intelligent objects that share data and information in changeable environment. It was the term coined by "Kevin Auston" the Executive Director of Auto-ID Labs at MIT. It is also represented by other names like web of things and embedded intelligence. The four important key features of an IoT environment are sensors, network, communication and computing technologies. With IoT, a new research area, and the researches are disjoint and growing exponentially in different fields. A list of research area/ and techniques used in multiple domains is given in Table 1.

Table 1
Research Areas/Techniques of IoT

Author	*Area of Research / Technique*
Miao Yun et al; 2010	Smart grid application of IoT [69]
Gronbaek, I. et al; 2008	Services and service logic [9]
Qian Zhu et al; 2010	Wireless sensor network [6]
Foschini, L. et al; 2011	M2M application for road traffic management [7]
Xiaolin Jia et al; 2012	Applications of RFID in IoT [8]
Jiong Jin et al; 2013	Cloud-based integration of systems and sendees \\2]
Zanella, A et al; 2014	Technologies and protocols of Urban IoTs for Smart City [2]
Lanzisera et al; 2014	Communication of energy and control information [131
HaoYue et al; 2014	ICN-based Internet architecture [17]
Taneja et al; 2014	M2M Gateway [19]
Yi-Bing Lin et al: 2015	Easy Connect system to manage IoT devices based on M2M [3]
Catarinucci, L. et al; 2015	Automatic monitoring and tracking in hospitals [4]
Mainetti et al; 2015	Bidirectional communication channel [11]
Sood et al; 2015	Software Defined Wireless Network [16]
Graham et al; 2015	Peak Detect Algorithm [18]
Debiao He et al; 2015	Healthcare [15]
Rahmani et al; 2014	An ubiquitous healthcare systems to improve human health and well-being T361
Jara et al; 2012	Health [38]

2.1. Computing Technologies for IoT

Computing activity includes design, process, structuring, and managing information with computers to make computer systems behave intelligently; the field of computing includes computer and information engineering. Computerized picture preparing abilities will be installed into ordinary articles, transforming them into an Internet-of-things, as regular items will get to be information generators, with sensors all over the place ceaselessly gathering an extensive amount of information about their setting and utilize and processors all over the place investigating and deriving valuable learning from the information [59]. Enormous Data (Big Data) is, generally,

an essential to take advantage of the Internet of Things. Without the correct information gathering set up, it'll be inconceivable for organizations to deal with all the data streaming in from installing sensors. This means, without Big Data, the Internet of Things can offer a venture minimal more than commotion [70]. Security of electronic gadgets is an unquestionable requirement in the realm of IoT. At the point when the security of a gadget is traded off, depending on the gadget for secure information trade, handling, or capacity is of concern. In the event that electronic exchanges, basic frameworks, for example, atomic plants, or implantable therapeutic gadgets are hacked, then the worldwide trust would be affected significantly. [71]

One of the most vital factors for the victory of the IoT is the capability of systems, services and solicitations to perform data mining. One of the pivotal parts of IoT is to drive brilliant collaborations with clients. To do as such, frameworks need to gather truths about clients and their using so as to set sensors and web assets, make fitting information examination, channel information and present clients the result or settle on savvy choices. Software engineering has connected factual strategies and constructed devices that permit you to perform Data Mining and concentrate valuable data out of the datasets. The absolute most critical utilizations of Data Mining are data anomaly detection, data clustering, data classification, feature selection, and time series prediction.

2.2. Data Mining

Data mining a computational process for finding unknown and new pattern. The techniques of Data Mining can be classified as Data classification, Clustering, Prediction and Association mining. Data classification is used when the collected data are associated with different classes. Classes can be groups which can correspond to situations, for instance, high or low activity.

Clustering denotes grouping of data on the basis of specific features and their values. It is the most common process of unsupervised machine learning. The techniques of clustering is partially based (K-Mean), Hierarchical based (Agglomerative), Density Based (DB-Scan).

Associations are used in retail sales to recognize patterns that are commonly purchased together. This process refers to the procedure of revealing the connection between data and defining association rules. The basic association rule mining techniques are Apriori, FPTree.

Classification problems, helps to model the existing relationships between a set of data items and a certain set of outcomes with class membership labels. Artificial Neural Networks (ANNs), K–nearest neighbors (KNNs), Support Vector Machines (SVMs), Linear Discriminate Analysis (LDA), Bayesian Belief Networks and Decision Trees (DT) are some of classification algorithms [75]. Prediction techniques are Linear, Multi-Linear and nonlinear Regression. Time series prediction provides the following feature an approximation of what future data can be based on a specific dataset that is already collected and analyzed. The most common application of time series prediction is meteorology and weather forecasting. Literature reviews [28] [34] [35] and survey [27] had been conducted in various data mining models [21] and data-driven system [37]. Data Mining techniques used IoT research in shown in the following table (Refer Table 2):

With the rapid development of IoT, the fundamental challenges are collecting and storing large volume of data, data from heterogeneous sources, knowledge extraction and security. The challenges of some of the domains are discussed in the next section.

3. CHALLENGES OR ISSUE OF IOT IN DIFFERENT DOMAINS

In Computer science and technology, the major challenges are Security, Trust and Privacy, Complexity, confusion and integration issues, Evolving architectures, protocol wars and competing standards, Concrete use cases and compelling value propositions [61]. The major challenges in the Communications domain are Zero effort

Table 2
Data mining techniques used in different domains

Author	*Research Area /Application*	*Technique*
Bin Guoa et al; 2013	Networking of IoT devices [10]	Big data dissemination
Meonghun Lee et al; 2013	Agriculture [20]	Correlation technique
Jianli Pan et al; 2015	An IoT framework with smart location-based automated and networked energy control [14]	Correlation
Tsirmpas, C. et al; 2015	Ambient-assisted living AAL [5]	Clustering algorithm
Kaur et al; 2010	General [40]	Big Data mining
Chen, N. et al; 2010	Challenges of enterprise Informationization [32]	Clustering algorithm
Rongrong Fu et al; 2011	An intrusion detection system [30]	Outlier Mining
Luyu Chen et al; 2012	Role of data mining technology and its leakage disadvantage [33]	Apriori Mining
Jianqi Shi et al; 2012	Environment [41]	Big Data Mining
Jia Ji et al; 2013	Massive information processing [29]	Sequence Mining algorithm
Wu He et al; 2014	Vehicular data cloud services in IoT for vehicle warranty study [22]	Classification & Prediction (Regression)
Jeu Young Kim et al; 2015	The home domain data [24]	Predictive modelling
Gole, S. et al; 2015	Social Media [26]	Freq Rule Mining
Ganz et al; 2015	Signal Data Processing [43]	Machine learning Algorithm
YuqingLan et al; 2015	Frequent item sets [44]	Association mining (frequent item set)

to connect large, dense populations of stationary and moving devices with high energy efficiency. Complete data security and privacy [62]. In Smart Cities [63] the major challenges, are looking after the problems and development priorities of cities within an innovation-led global world, and to achieve this, the city authorities have to undertake initiatives that create the physical-digital environment of smart cities, realizing useful applications and e-services. In the field of Health and Fitness [64], the major challenge is Location awareness which is the essential requirement for 'Geo-fencing', where a person's location can be restricted. People may feel that personal information about one's physical health is private and should not be shared; when it is IoT supervises chronic disease. In the Automotive industry [65], Vehicle security and customer privacy are main challenges which go hand-in-hand with developments in software and mobile-device security. Connected cars need a real-time communication layer to stream data and signal between their fleet, dispatch, and the consumer on the app. In a Smart Environment domain, the major challenge is the E-waste disposal problem. The next generation of IoT devices will turn obsolete due to the hardware upgrade. Another challenge is energy consumption as it is massive. In Smart Water domain, The IoT can help government and utilities work together to improve governance of the water ecosystem, by creating greater insight into both supply and demand. Some challenges are - Improving Yield, Lowering Demand, and Automating Use. The IoT with Smart Homes may limit or disturb the resident's daily routine, decreasing his or her greatest comfort, pleasure, and well-being. In Agriculture domain, the quality, quantity, sustainability and cost effectiveness of agricultural production are the major challenges.

3.1. Challenges in Business Domain

The Internet of Things helps in providing marketers bigger vision in linking to consumers with important data collected from mobile devices, with the challenge being how to best influence the information [67]. In industrial

domain, an analysis of economic value and ROI (Return On Investment) [68] can help industries in determining where to combine IoT (Industrial of Internet of Things) technologies, the challenge for device manufacturers is of settling on capabilities Developing New Engineering Skills [66] to handle the operations technology—the implementation and integration of sensors, actuators and similar devices behind material handling solutions—needed for IoT applications; Marketing New Capabilities to establish their companies as the trusted provider of new solutions; Reaching New Buyers by hiring sales associates who have relationships with the key players. IoT systems need to be Adaptive and Scalable through software or added functionality that integrates with the overall solution. Security is a key Issue as the bad data injected into system is able to damage data via data breach. Investing in Flexibility is Crucial as it is no small investment and the risk is high. The Recent work of IoT business is shown in Table 3.

Table 3
IoT in business

Authors	*IoT in Business*
Jingzhao Li et al; 2010	Zigbee data collection technique [39]
Domingos et al; 2010	Ad-hoc changes in business [58]
Qian Xiaocong et al; 2010	Business operations field [51]
Xueqin Jia et al; 2011	Three types of IoT communication infrastructure and business models [54]
Klaus Sperner et al; 2011	The adaptation of RFID in industries. [50]
Lei Yuan et al; 2012	GIS with DW technology [42]
Seppo Leminen et al; 2012	Types of IOT business models. [47]
Zhengshan Luo et al; 2012	Logistics inventory based on RFID technology [48]
Rongrui Yu et al; 2012	RFID technology [49]
Wang Wei et al; 2013	Cause and effect feedback loop between technology innovation and business modes innovation [56]
Berkers et al; 2013	Multi-sided business model [57]
Xin Song et al; 2014	Parallel processing [45]
Xueyun Li et al; 2014	PPDM techniques based on a PPDM framework [46]
Zhuming Bi et al; 2014	Manufacturing enterprise systems. [52]
Ide et al; 2015	Business model for after-sales services [53]
Yu Zhang et al; 2015	E-business model designed for the IoT E-business [55]

4. PROPOSED MODEL FOR BUSINESS DATA MINING SYSTEM

4.1. Data Mining Need in IoT

Data mining techniques are frequently used to find the stocking options and inventory warehousing. In sales and forecasting, Regression analysis can be used to predict the product, customer will buy or the associated products to be sold. Marketing data is used to find the purchase pattern, demographics of customers and target to market a product in a specific location. Social media data help to retain customers. Clustering and classification techniques are used for Segmentation and creating custom products designed for market segments. Product, Production and customer data are used in the feedback analysis/opinion mining**.**

4.2. Dependent and Independent Variables

A dependent variable is the thing that you measure in the trial and what is influencing amid the analysis. The reliant variable reacts to the autonomous variable. It is called subordinate since it "depends" on the autonomous

variable. In a logical examination, you can't have an indigent variable without a free variable. Sales growth, sales revenues, size of transactions and repeat sales are the dependent variables [73]. Independent Variable is a free variable you have control over, what you can pick and control. It is generally what you think will influence the subordinate variable. Now and again, you will most likely be unable to control the autonomous variable. It might be something that is as of now there and is altered, something you might want to assess regarding how it influences something else. Price, product, place, promotion, customer demographics are the independent variables [74]. Product marketing acceptance can be given by the following variables such as product quality, brand name and price of the product where product marketing acceptance is the dependent variables while product quality, brand name, pricing are the independent variables.

4.3. Bayesian Belief Networks

Bayesian Belief Networks can be defined as the full joint distribution over the variables more compactly with a smaller number of parameters. It takes advantage of conditional and marginal independences among random variables. It is a graphical model where each node is a discrete or continuous variable. Research is needed to develop a data mining technique for dependency among set of variables collected from various sensors and a process that make computing easier and has better speed and accuracy for huge datasets.

Propose data mining system can be discussed under five layers:-

(i) Sensor Devices: They are used to collect the Marketing data. Mobile devices, Bar code Scanners, Customer ID-card Scanner can be devices used to collect the data. Data can also be collected from people (Internet of People).

(ii) Data Types: The data collected can be structured (product, customer data), semi-structured data (product specification), and unstructured data (customer feedback, a sales report). These data are to be cleaned, integrated, transformed and stored. There are many challenges for traditional approaches for storage and analysis.

(iii) Data Storage & Processing: Big data storage environment.

(iv) Business Services: A belief network is a directed model of conditional dependence among a set of random variables. Bayesian network shows conditional probabilities between the variables and is used for reasoning under uncertainty. To identify hidden and missing values can also be achieved by belief network.

(v) Knowledge discovery and Interesting patterns from the data.

The above layers are used to propose the business model and the Proposed Model for Business Data Mining System is shown in Figure 1.

5. CONCLUSION

Data mining technologies can be combined with IoT for finding important interesting pattern in marketing data, support and decision making. In this paper, Survey of IoT under various domains and in specific to business domain is discussed. An understanding of Data mining techniques and their need in various business domains are captured. Bayesian Belief Network as data mining services is identified. Based on the survey of the current research, a suggested marketing data mining model is proposed. Further research analysis can be carried down in the following fields of business like Finance, HR, Accounting and Entrepreneurship.

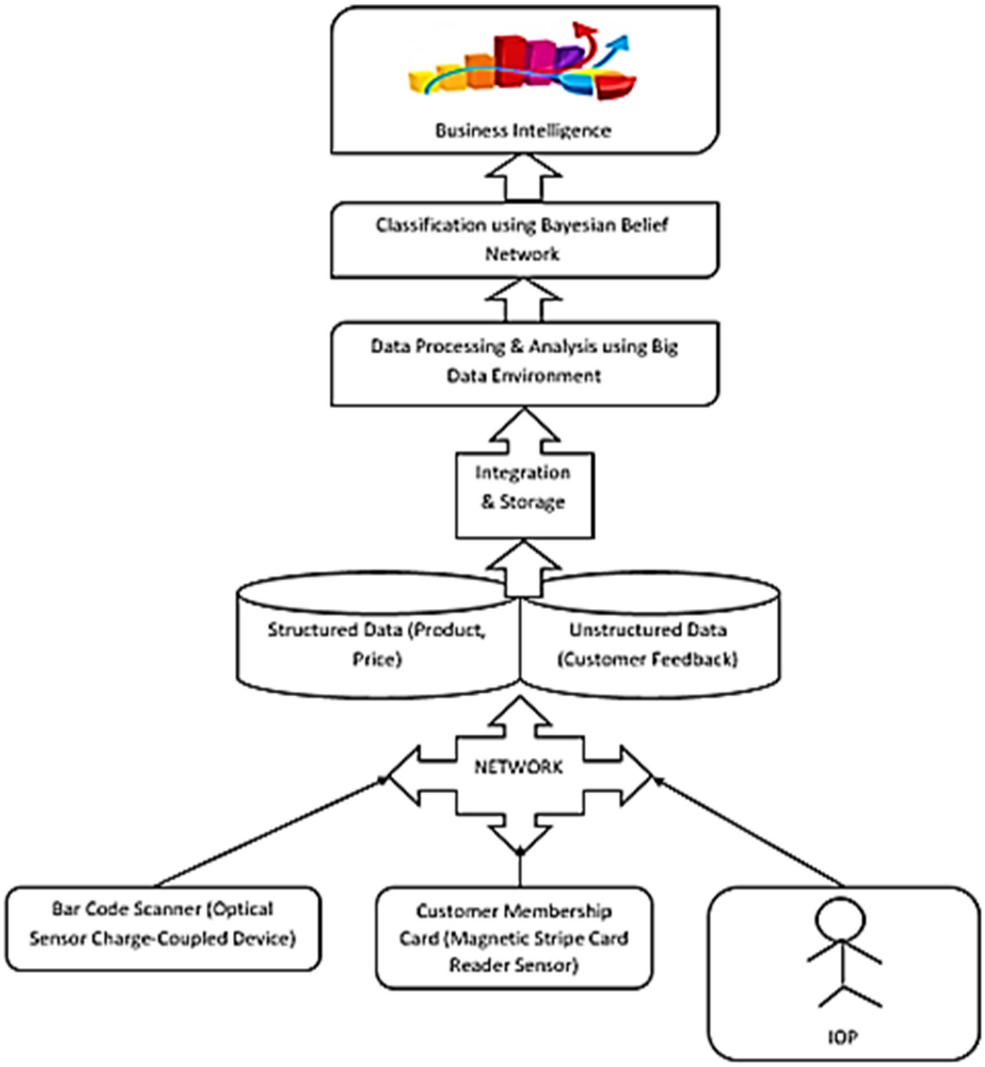

Figure 1: Proposed Model for Business Data Mining System

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