

# Customer Churn Prediction in Telecommunication

## A Decade Review and Classification

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### Abstract

Acquisition and the retention of customers are the top most concerns in today's business world. The rapid increase of market in every business is leading to higher subscriber base. Consequently, companies have realized the importance of retaining the on hand customers. It has become mandatory for the service providers to reduce churn rate because the negligence could be resulted as profitability reduction in major perspective. Churn prediction helps in identifying those customers who are likely to leave a company. Telecommunication is coping with the issue of ever increasing churn rate. Data mining techniques enable these telecommunication companies to be equipped with effective methods for reducing churn rate. The paper reviews 61 journal articles to survey the pros and cons of renowned data mining techniques used to build predictive customer churn models in the field of telecommunication and thus providing a roadmap to researchers for knowledge accumulation about data mining techniques in telecom.

**Keywords:** Retention, Higher Subscriber Base, Customer Churn, Telecommunication, Data mining.

### 1. Introduction

Customer churn is referred to as the inclination of a customer to leave a service provider. (Chitra Phadke, Huseyin Uzunalioglu et al., 2013; Vivek Bhambri, 2013; Zhen-Yu Chen et al., 2012; Clement Kirui, Li Hong et al., 2013; Yaya Xie a, Xiu Li et al., 2009; Chandar, Laha and Krishna, 2006). Customer churn prediction is the process of identifying those customers who could leave or switch from the current service provider company due to certain reasons (Coussement and Van den Poel, 2008; Buckinx and Van den Poel, 2005). The

major aim of churn prediction model is to identify such customers so that the retention strategies could be targeted upon them and the company may flourish by maximizing its overall revenue (Junxiang Lu, 2003).

Customer churn prediction has been raised as a notorious issue in many fields such as telecommunication (Umman, Tuğba, Şimşek, & Gürsoy, 2010; Verbeke et al., 2011; Tarik Rashid, 2008; Adnan Idris et al., 2012; Bingquan Huang et al., 2012; Hung, S. Y. et al., 2006), Credit Card (Guangli Nie, Wei Rowe et al., 2011), Internet Service Providers (Afaq Alam Khan et al., 2010; B.Q. Huang et al., 2009; Li, S. T., Shue, L. Y., 2006), Electronic Commerce (Chang, S. E., Changchien et al., 2006; Changchien, S. W., Lee, C. F., & Hsu, Y. J., 2004; Etzion, O., Fisher et al., 2005; Kuo, R. J. et al., 2005, Kim et al., 2004), Retail Marketing (Chen, M. C., Chiu, 2005), Newspaper publishing companies (Dries F. Benoit b et al., 2010; Douglas, S., Agarwal, D., and Alonso, T., 2005), Banking (Yaya Xie a, Xiu Li, E.W.T. Ngai b, Weiyun Ying, 2009; Koh, H. C., & Chan, K. L. G., 2002; Au, W. H., & Chan, K. C. C., 2003; Chiang, D. A., 2002) and financial services (B Larivière, D Van den Poel, 2004).

But among all other fields, telecommunication companies over the years are experiencing the highest annual churn rate from 20% to 40% ( Jae-Hyeon Ahna, Sang-Pil Hana and Yung-Seop Leeb, 2006; Kim, Park, & Jeong, 2004; Berson, Smith, and Therling, 1999; Madden, Savage, & Coble-Neal, 1999). This has financial implications on a company, as it costs 5 to 10 times more to add a

new customer than retaining an old customer with the company (Junxiang Lu, 2003).

Data mining, as a major field of computer sciences, is defined as the process of extracting hidden patterns from very large datasets by using statistical, mathematical, artificial intelligence and machine learning techniques (Turban, Aronson, Liang, and Sharda, 2007; Berson et al., 2000; Lejeune, 2001; Ahmed, 2004 and Berry and Linoff, 2004; Lau, Wong, Hui, & Pun, 2003).

The organizations may have an ocean of data but still they are starving for information or more specifically for valuable knowledge. Data mining tools could best help these organizations to extract hidden patterns of useful information (Vivek Bhambri, 2013; Berson et al., 2000).

This paper aims at reviewing the research intensity during the year of 2002 to June, 2013. It subsequently discusses the churn prediction problem specifically in telecom as section 2. Then the research methodology would be discussed along with flow chart view in section 3. Afterwards, the heart of paper, the comprehensive analysis in four different dimensions would be presented as section 4 along with the evaluation and interpretation of results. Also the challenges faced by the researchers in this sector would be highlighted in section 5. Limitations as well as findings of the paper will be described in section 6 and 7. Section 8 concludes the paper.

## 2. Customer Churn in Telecommunication

Telecommunication has gained one of the top positions in the list of fastest growing industries of the world by covering 90% of its population (Rajanish Dass and Rumi Jain; 2011). It is one of the sectors where customer base plays a very important role in maintaining the revenue (Adnan Idris, Muhammad Rizwana, Asifullah Khan, 2012). The telecommunication sector is facing a severe threat of customer churn (Jae-Hyeon Ahn, Sang-Pil Hana and Yung-Seop Lee, 2006; Kim, Park, & Jeong, 2004; Berson, Smith, and Therling, 1999; Madden, Savage, & Coble-Neal, 1999).

According to Wie and Chiu, 2002, wireless telecom industry is facing with the threat of losing 27% of its customers every year, which would definitely result in huge revenue loss. It is also an adopted fact that adding or acquiring a new customer costs 5 to 10 times more to add a new customer than retaining an old customer with the company (Junxiang Lu, 2003). Therefore, Richeldi and Perrucci, 2002, suggest that the company should

pay more attention to retain its current subscribers rather than adding new ones.

Nowadays business firms pay more attention to make firm relationship with their customers (Zhen-Yu Chen et al., 2012; Coussement and Van den Poel, 2008; Ngai et al., 2009; Kim & Yoon, 2004).

Hence it has become a belief that the best marketing strategy is to retain the existing subscribers or more simply to avoid customer churn (Golshan Mohammadi et al., 2013; Chih-Fong Tsai et al., 2009; Kim, Park, and Jeong, 2004; Kim and Yoon, 2004).

To tackle with this problem, data mining techniques have been proved as the best tools to fight against ever increasing customer churn rate (Au, Chan, and Yao, 2003; Bin, Peiji, and Juan, 2007; Coussement and den Poe, 2008; Hung, Yen, and Wang, 2006; John, Ashutosh, Rajkumar, and Dymitr, 2007; Lazarov and Capota, 2007; Wei and Chiu, 2002).

## 3. Research Methodology

Because journals are considered as the most reliable source of research (Nord & Nord, 1995), so firstly, some renowned online journal databases were explored to get a comprehensive academic literature on the topic. Here is a list:

- Elsevier
- IEEE Xplore
- SpringerLink
- ScienceDirect
- ACM Digital Library
- Microsoft Academic Search

The search criteria based on the search strings by following the syntax of each of the database. It originally produced 834 articles. As a next step, the articles actually related to the topic were filtered out. The criteria for the inclusion and exclusion of articles are as follow:

- The articles containing the keywords written in search string.
- Only those articles that have been published in significant journals. Conference papers, newsletter, lecture notes, books, doctoral dissertations, un-published work and conference proceedings were excluded.
- The search criteria were restricted to from the year 2002 to 2013.
- Only those articles were selected that were related to the telecommunication world.

- Then these selected articles were distributed into four different classes:
  - *Classification by Techniques being used for predicting customer churn.*
  - *Classification by Journals in which the papers were published.*
  - *Classification by the type of data set being used in research; wireless or land line.*
  - *Classification by Year in which the articles were published.*

Fig.1 depicts the overall scenario of research process described earlier in more comprehensive way.

#### 4. Distribution of Articles

A detailed distribution of 61 journal articles has been shown in Table 1 along with their title, publication year and author names.

Total 61 articles were finally selected for analysis in four different dimensions:

- Distribution of articles by Dataset Type
- Distribution of articles by Techniques
- Distribution of articles by Journals
- Distribution of articles by Publication Year

##### 4.1 Distribution of articles by Dataset Type

No one can deny the importance of data in an organization. It is truly called as an "asset". But it becomes to its intense significance level when we talk about predictive modeling.

The fact is that the quality of our predictive model is strictly dependent upon the quality of data being used for it. Un-reliable data will definitely lead to incorrect results (Jiayin Qi ,Yingying Zhang, Huaying Shu , Yuanquan Li, Lei Ge, 2006). In predictive modeling, data set plays the vital role.

Telecommunication sector could be divided into two sub categories in accordance with service providing nature. These two are Fixed line/ Land line Telecommunication and Cellular /Mobile /Wireless Telecommunication Service providers.

The classification of 61 articles in the above mentioned perspective has been shown in Fig.2. The figure is depicting the fact that among three categories, wireless telecom has grabbed the major part of research.

Table 1: Classification by Dataset Type

Data Type	Frequency	Percentage
Land Line	3	4.918032787
Wireless	35	57.37704918
Dataset not specified	23	37.70491803
<b>Total</b>	<b>61</b>	<b>100</b>

Table 1. is showing the statistics that 4.92% (3 among 61 articles) research has been done on taking fixed line telecommunication data type. And 57.38% (35 among 61) papers worked upon wireless or mobile telephony churn prediction.

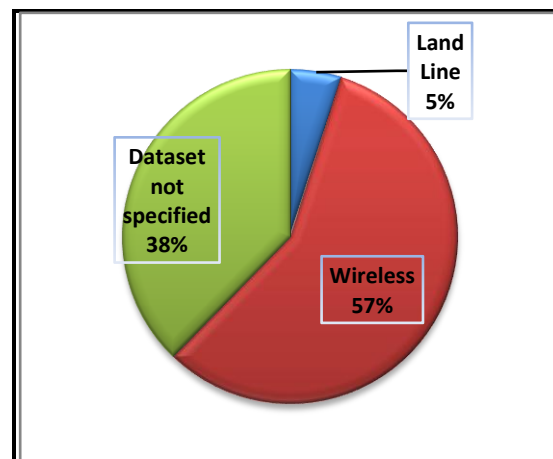


Fig. 1 : Classification by Dataset Type

The major reason behind the very little research work in fixed line area is the less amount of qualified information (Jiayin Qi ,Yingying Zhang, Huaying Shu , Yuanquan Li, Lei Ge, 2006). Customer call details, demographic, complaints, billing information and contractual data is usually used for predictive model building in telecommunication (Chih-Ping Wei, I-Tang Chiu, 2002). However, in fixed line service providers, researcher have access to only customers' call details and billing information (Jiayin Qi ,Yingying Zhang, Huaying Shu , Yuanquan Li, Lei Ge, 2006). This is the reason that invokes a challenge for researchers to build a predictive model with limited information for fixed line churners (Jiayin Qi ,Yingying Zhang, Huaying Shu , Yuanquan Li, Lei Ge, 2006).

Fig.3 depicts another split view of frequency of journal articles in terms of wireless and fixed line telephony which ultimately strengthens above mentioned facts.

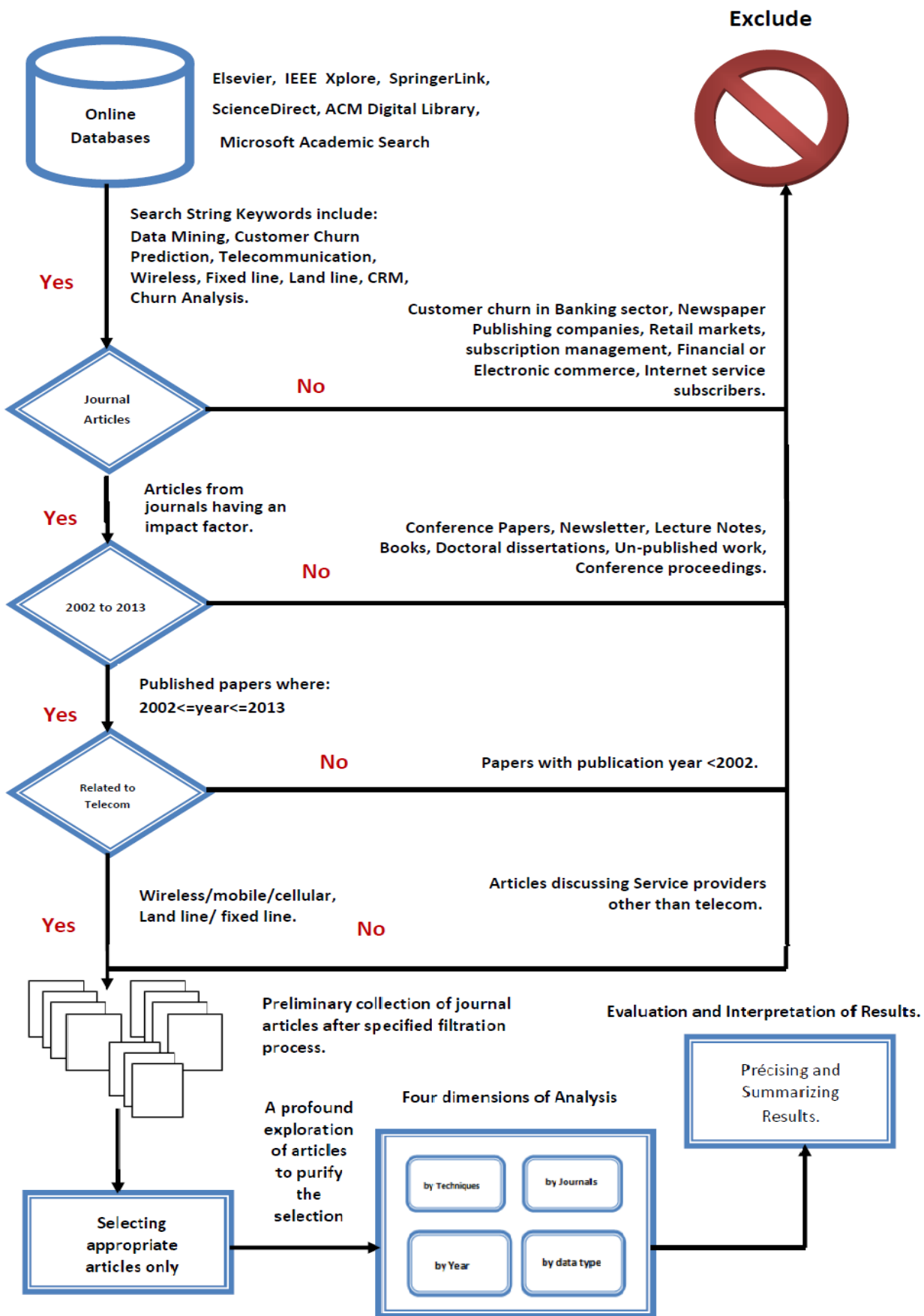


Fig. 2 : Research Methodology

Table 2: Classification by Techniques

Technique	Frequency
Decision Tree	26
Neural Network	16
Logistic Regression	15
Cluster Analysis	10
Genetic Algorithm	6
Markov Model	4
Naïve Bayes	4
k-nearest-neighbor	3
Bayesian Belief Network	3
Association Rule	2
Support Vector Machine	2
Bagging	2
CART	2
CHAID	2
K-Means	1
Fuzzy C means	1
influence diffusion model	1
Chr-PmRF	1
partial least squares (PLS)	1
C5.0	1
Structural Equation Model	1
<b>Total</b>	<b>104</b>

#### 4.2 Distribution of articles by Techniques

Table 3 shows the distribution of journal articles by the technique being used for model building. Total 104 types of techniques have been used in 61 articles. Here it is a point to be noted that one article may have used more than single technique for model building.

Among these techniques, Decision Tree has been used most commonly. It has been used in 25% of articles. Neural network and Logistic Regression have been used with 15.4 and 14.4 percentage. Following are the top three popular techniques have been reviewed in the light of academic literature:

**Decision Trees:** Decision tree is used to predict future trends and to extract models based upon the interrelated decisions (Chu , Tsai and Ho, 2007; Berry & Linoff, 2004; Chen et al., 2003; Kim, Song, Kim, & Kim, 2005). It works upon the principal of classifying data into specific classes in

accordance with their properties. Internal nodes follow the root node by covering all occurrence possibilities (Buckinx, Moons, Poel, & Wets, 2004; Chen et al., 2003 ;). Thus a tree is formed with its unique arc describing particular responses.

**Neural Network:** Currently, neural networks are used by researchers in the field of classification, clustering and prediction (Berry & Linoff, 2004; Turban et al., 2007). When applying neural network technique, it converts the data into dimensional array of neurons in an orderly manner which ultimately forms a prediction hierarch (Tsai and Lu, 2009; Song, Kim, Cho, & Kim, 2004 ).

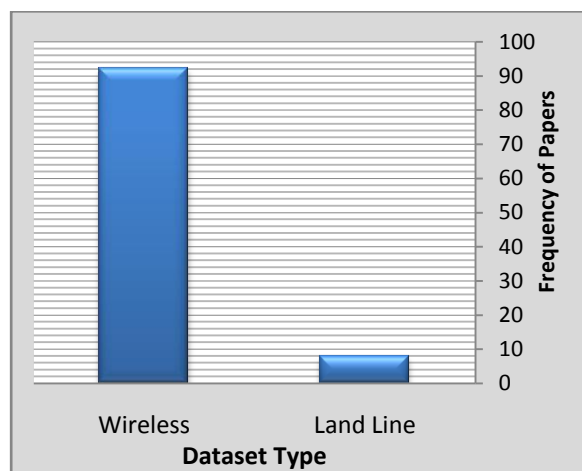


Fig. 3 : Classification by Two Dataset Type

**Regression:** Regression is also very popular technique for predicting behavior. It determines the impact of many independent variables to predict the possible reliance of one or more than one dependent variables (Bingquan Huang et al., 2012; Michel Ballings, Dirk Van den Poel, 2012; Marcin Owczarczuk, 2010; Jiayin Qi et al., 2006).

**Cluster Analysis:** Mainly, cluster analysis is done under the field of machine learning where objects with similar nature are kept in one cluster. It is also used for reliable statistical analysis of data (J. Hadden, A. Tiwari, R. Roy, D. Ruta, 2007; Larivi\_ere and VandenPoel, 2005).

#### 4.3 Distribution of articles by year of publication

The distribution of articles by the year of publication is shown in Fig.5. the decade along with the year of 2013 till June has been shown. It could be observed that 2012 and 2010 are the years where telecommunication sector got most research material on churn analysis.

Table 3: Classification by Publication Year

Year of Publication	Frequency of Papers
2002	1
2003	3
2004	2
2005	3
2006	7
2007	6
2008	4
2009	3
2010	10
2011	7
2012	11
2013 (June )	4
<b>Total</b>	<b>61</b>

Table4: Classification by Journals

Journals	Frequency
Expert System with Applications	16
Telecommunications Policy	6
Decision Support Systems	6
Data Mining and Knowledge Discovery	2
Advanced Data Mining and Applications	2
International Journal of Computer Applications	2
International Journal of Intelligent Technology	2
IEEE Transactions on Knowledge and Data Engineering	1
Annals of Operations Research	1
Bell Labs Technical Journal	1
Computers and Electrical Engineering	1
Computers and Operations Research	1
Emerging Research in Artificial Intelligence and Computational Intelligence Communications in Computer and Information Science	1
European Journal of Operational Research	1
GE-International Journal of Management Research	1
IEEE Transactions on Evolutionary Computation	1
International Journal of Computer Science Issues	1
International Journal of Advanced Computer Science and Applications,	1
International Journal of Biometrics and Bioinformatics (IJBB)	1
International Journal of Production Research	1
Journal of Intelligent Manufacturing	1
Journal of Interactive Marketing	1
Journal of Organizational Computing and Electronic Commerce	1
Journal of Strategic Marketing	1
Journal of the Operational Research Society	1
Journal of the School of Business Administration	1
Knowledge-Based Systems,	1
Machine Learning and Data Mining	1
Marketing Intelligence and Planning	1
The Service Industries Journal	1
Applied Economics Letters	1
Systems Engineering — Theory & Practice	1
<b>Total 32 Journals</b>	<b>61 Papers</b>

#### 4.4. Distribution of articles by Journals

Table 4 shows the distribution of articles by journal. Total 32 journals were explored to find articles related to churn prediction in telecommunication sector. "Expert System with Applications" leads the race with 16 significant articles. "Telecommunication Policy" is following the race with 6 papers published in context of customer churn prediction.

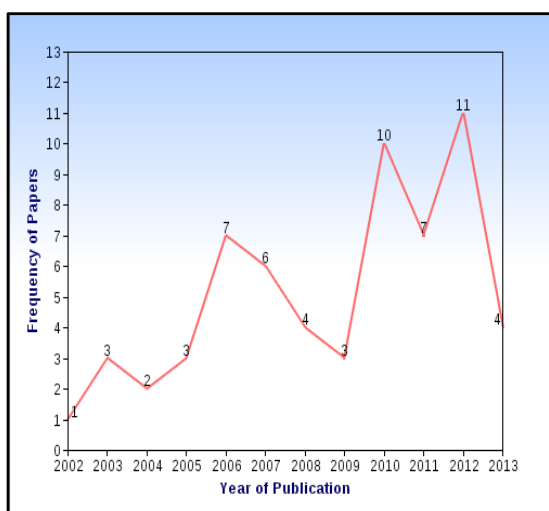


Fig.5: Classification by the Year

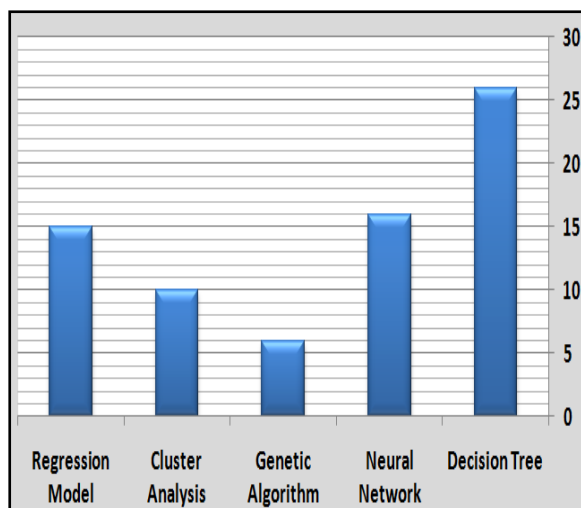


Fig. 4: Classification by mostly used techniques

## 5. Challenges

Researchers may face many problems in the process of modeling a churn prediction model. The major one is the missing or incomplete datasets for both wireless and fixed line telecommunication (B.Q.Huang a, T.-M. Kechadi , B. Buckley , G. Kiernan , E. Keogh , T. Rashid , 2010). On the other side, some telecom companies provide a very large enough data set which is sometimes very hard to handle (Adnan Idris, Muhammad Rizwan , Asifullah Khan, 2012) regarding with the problems of noisy data.

In the opinion of Yaya Xie , Xiu Li , E.W.T. Ngai , Weiyun Ying , 2009 and B.Q.Huang a, T.-M. Kechadi , B. Buckley , G. Kiernan , E. Keogh , T. Rashid , 2010, one of the biggest challenges for the researchers of telecom churn prediction is the imbalanced nature of data (Zhao et al., 2005).

The imbalanced term refers to un-equal ratio of regular customers with churners. Zhao et al., 2005 declare the fact that mostly, the number of churners' data is only of 2% of the total data which would certainly create problem in context with the reliability of the predictive model. Because of the confidential nature of telecom dataset, they are not publically available (Vivek Bhambri, 2013; B.Q. Huang et al., 2010). High dimensionality of these datasets is also another big issue (Adnan Idris et al., 2012).

While talking about the techniques mainly used for model building, XIA Guo-en and JINWei-dong, 2008, divide them into two major classes named as classification and artificial intelligence. The first class includes decision tree, logistic regression, naive bayesian classifiers and clustering are good for analyzing qualitative and continuous data and afterwards interpreting results but these techniques

do not guarantee the appropriate accuracy of prediction model for large enough, highly dimensional, non linear or time series datasets (XIA Guo-en et al.,2008).

The second class including artificial neural network, self organization maps and evolutionary methods solve the problems of first class techniques with better prediction precision(XIA Guo-en et al.,2008). It means that exploring new methods or techniques for prediction model is very important.

## 6. Limitations of Research

As it has been mentioned earlier that only strong references were utilized to make the research more reliable in every perspective. But as nothing is perfect so this study has also some certain limitations:

- Firstly, only 61 articles have been review published from 2002 to 2013. More articles could be extracted by expanding the research duration.
- Secondly, the research was done under the search string including the main terms related to "customer churn", "churn prediction", "telecom""data mining" and "CRM" but the articles belonging to the churn prediction in telecom but not having any of these keywords could not be included in the review.
- Lastly, the research was restricted to only 6 online journals. Other academic journals may provide some more results.

## 7. Findings of Research

Although the research has certain limitations but yet it provided some implications:

- The majority of articles were related to wireless telephony. A very less amount of work (only 3 out of 61 articles) has been done in the field of fixed line telephony.
- The major reason behind the very little research work in fixed line area is the less or limited amount of qualified information.
- Decision tree has been emerged as the most commonly used technique for predicting churn rate.
- Un-availability or too large datasets with noisy nature are two major challenges in context of data quality constraints.
- High dimensionality and imbalanced nature of data are the barriers towards a précised prediction model.

- Although the classification techniques are good for analyzing qualitative and continuous data and afterwards interpreting results but these techniques do not guarantee the appropriate accuracy of prediction model for large enough, highly dimensional, non linear or time series datasets.
- Artificial intelligence and machine learning techniques work with high dimensional, bulky, non linear datasets with better prediction accuracy but complicated in terms of real world applications.

## 8. Conclusion

Now a days, telecommunication industry is struggling with a notorious issue of customer churn. The issue has serious allegation on customer loyalty along with revenue loss in major perspective. The only way is to retain the on hand customers by using customer churn prediction model. Data mining techniques help telecom industry in this perception by providing techniques to identify such customers so that retention actions could be targeted upon them.

The paper, in the beginning, highlighted the immense threat of customer churn for telecom companies by giving statistical reasons. Customer churn problem was discussed and reviewed both in general and subsequently in specific mode. Afterwards, a comprehensive comparison of selected articles was carried out in four intentional dimensions. 61 articles were reviewed in detail by year of publication, used technique, relative journal and by dataset type.

The findings of the research make a contribution in the field of customer churn predictive modeling in telecommunication. Thus the paper draws a sketch line for the researchers for reviewing and accumulation of the trends about data mining applications in the field of telecommunication.

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