Chapter 6

On the Use of Hybrid Heuristics for Providing Service to Select the Return Channel in an Interactive Digital TV Environment

Marcos César da Rocha Seruffo,
Ádamo Lima de Santana,
Carlos Renato Lisboa Francês and
Nandamudi Lankalapalli Vijaykumar

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.69615

Abstract

The technologies used to link the end-user to a telecommunication infrastructure, has been changing over time due to the consolidation of new access technologies. Moreover, the emergence of new tools for information dissemination, such as interactive digital TV, makes the selection of access technology, factor of fundamental importance. One of the greatest advantages of using digital TV as means to disseminate information is the installation of applications. In this chapter, a load characterization of a typical application embedded in a digital TV is performed to determine its behavior. However, it is important to note that applications send information through an access technology. Therefore, this chapter, based on the study on load characterization, developed a methodology combining Bayesian networks and technique for order preference by similarity to ideal solution (TOPSIS) analytical approach to provide support to service providers to opt for a technology (power line communication, PLC, wireless, wired, etc.) for the return channel.

Keywords: heuristics, model decision making, service provider, return channel, interactive digital TV

1. Introduction

The interactive digital TV (DTV) environment allows a new class of services around television content that was to broadcast, where interactive programs can be employed allowing user interaction. The interaction implies totally different approaches to reflect and produce television content. In addition, one must keep in mind that such issue makes telecommunication infrastructures to deal with new load of data.

In this aspect, service providers have to plan the implantation of technology, based on these new demands that will be a part of computing environments. The diversity of broadcast applications and the usage of an interactive channel, as external communication in the Brazilian context, lead to a case-study with the objective to consider the social inclusion specified in Brazilian Presidential Decree No. 4901.

It is even more necessary as the Brazilian digital TV system (SBTVD) presents as a promising alternative when considering digital inclusion, since the television, besides being present in more than 90% of Brazilian homes, according to national survey by household sample of Brazilian Institute of Geography and Statistics (IBGE) [1]. It is also available to virtually all social classes, in all regions of Brazil, which is not true in the case of other communication devices, such as computers.

Therefore, one can consider that the digital TV has a great scope and it should not be restricted to a mere process of improving the quality of transmission. One must also consider it to be used as a tool for digital inclusion, naturally with strong possibility of interactivity.

In this context, a universe of activities involving production of audio/visual content to include applications that allow the user to interact with the interactive TV applications has been growing. The possibility to offer applications to viewers by means of interactive digital television (iTV) [2] originates a new production chain involving programs and applications development of interactive character. Based on this aspect, service providers should be concerned with the diversity of applications and services that can be offered.

One of the main challenges, for social and digital inclusion through digital TV, is to enable the population, mainly located in areas of difficult access and low-income, to gain access to services such as t-health and t-education. Besides, it becomes a major challenge to access providers to use the traditional TV broadcast, the interaction with multiscreens (tablets, PC, TV, smartphones, etc.) allowing access with different digital services, to enable facilities such as purchases via online, chats with or without video, etc. However, this challenge implies on making networks available with a larger capillarity, in particular, when comparing to services available now.

Thus, it is fundamental to address the issue of first mile, i.e., the first technology with which a user connects to a telecommunication network; this term is used synonymously with technology access that ensures the interactivity (return channel) service. Studies must be conducted to service providers to have an idea of system performance characteristics. In order to secure this, scenarios must be studied and understood so that applications embedded in SBTVD can be used by end-users. Besides, solutions must be devised in order to facilitate providers to predict possible problems in the system.

Research should be conducted considering the following features: return channel and quality of service (QoS). Besides, such features must be taken into account in a combined manner with applications, amount of interactions that such applications require, as well as other aspects for ensuring effectiveness to deal with significant volume of services providing interactivity.

As a contribution, a provision of service strategies for selecting return channel within interactive digital TV environment is proposed in this chapter. This approach is based on a combination of measurements and analytical/artificial intelligence models, enabling decision making from a set of QoS parameters. With respect to measures, test results are obtained for measuring the delay, throughput, jitter, active connections, response time, data dropped, and number of retransmissions from access technologies. With respect to the analytical/computational intelligence models, two decision-making approaches—Bayesian network (BN) and technique for order preference by similarity to ideal solution (TOPSIS)—have been deployed to determine the best choice from the alternatives studied.

The selection of TOPSIS and Bayesian networks is encouraged by several factors, such as ease of implementation, use in several solutions (as shown in Section 2), experience of the research group in the use of these models, results obtained from the combination of these models, and the use of a hybrid proposal ratifies the excellence of the proposed model. It is necessary to reinforce that the proposal discussed here is quite generic and flexible making is easier to consider another parameters or technologies and thus adapting it to be prepared for the other kinds of decision making.

2. Related work

Based on constant advancement in technologies, several studies published in the areas of heuristics, service provider, digital TV, access technologies, and methods for decision making show that strategies for providing service to select the return channel are in the spotlight.

Usually, digital TV systems make use of the layered architecture to be represented. Lower layers provide services to upper layers. Architectures are similar but different with respect to modulation, coding, compression, transmission, running applications, and adopted middleware. In particular, for Brazil, the adopted middleware is known as Ginga.

According to Ref. [3], iTV systems allow a new variety of services over broadcast TV content. Therefore, user interaction through digital TV apps is possible. This implies in a new means to manipulate the content (from the user's point of view), because of this, stimulate a different form to produce and think about TV. This chapter presents interactive service provider architecture for iTV systems, from a service-oriented architecture and guaranteeing a standardized communication among client apps and services with interactivity.

SBTVD and its characteristics are discussed in Ref. [4]. It elaborates the analysis of several aspects with respect to the definition of SBTVD and relates the electronics industry's impact on its productive chain. It also identifies features and functions that are to be considered to be implemented in the system and even goes further by discussing the potential of sales of digital signal receivers.

Another paper [5] gave a relevant contribution by showing a variety of studies that addressed the connection between the end-user and telecommunication infrastructure. Authors in Ref. [6] address the concern in the behavior of networks given the increase in the number of end-users with access to systems like asymmetric digital subscriber line (ADSL), cable modem, wireless, power line communication (PLC), and optical fiber.

Reviewed literature showed technologies employed as a return channel for interactive digital TV. For example, based on the number of active subscribers, several models were designed and simulated to evaluate the performance of the system's capacity [7]. It brought evidences that WiMAX would perfectly fit as a return channel for digital TV interactive application. In Ref. [8], the tests use PLC as a return channel to test how effective it is for applications such as e-health and e-learning.

Traditional TV sets have been enhanced with new services due after digital TV has been introduced [9]. For example, set-top boxes enable access to Internet to send emails. This new approach allows interaction of the viewers with TV stations. The most important contribution of Ref. [9] is the analysis whether an ad-hoc wireless network is feasible to be used as a return channel as such networks are cheap and flexible.

Among the range of access technologies available in the market, the selection of access technology to be used by the service provider is the subject much discussed in the literature. As in Ref. [10], that uses the stochastic control technique, Markov decision process (MDP) studies and examines the relationship between optimal decisions that should be applied by the service provider.

Literature also shows that infrastructure for telecommunication must consider its improvement, as it is clear that there is an increase in the number of digital TVs if bottlenecks are to be avoided. Some methods have been suggested in Refs. [11, 12] to control such bottlenecks due to heavy telecommunication traffic. The method suggested is to enable access for volatile traffic and this is based on sample monitoring.

There are several tools to monitor and control and these may be employed to measure the system load and evaluate how bottlenecks can be avoided. In this sense, it becomes necessary to understand multicriteria decision-making methods.

Authors in Ref. [13] present an overview of various approaches to multicriteria decision making by comparing their performances, which can be used as a basis for the study of models employed for decision making.

One approach for the first mile problem to select user's connection can be found in Ref. [14]. It is based on multicriteria analysis and can be considered as a combination model as it addresses issues such as multicriteria ranking, knapsack-like problems, hierarchical clustering, and morphological synthesis.

Heuristics for multicriteria decision making have been widely used, as shown in Ref. [15], with several papers addressing algorithms for selecting the return channel in heterogeneous environments, such as Refs. [16–21], with different kinds of models.

Bayesian networks are graphical models for reasoning based on uncertainty, where nodes represent the variables (discrete or continuous) and arcs represent the direct connection between them. From the set of computational intelligence models surveyed in the literature, Bayesian Networks were chosen to model decision making to extract knowledge of a typical iTV application.

The use of Bayesian networks with multicriteria decision-making methods is found in the literature, like Ref. [22], in which the authors show a problem of multicriteria decision making. The authors aim is to select the most suitable solution (given many alternatives). The idea is to propose a method that centers on the person since the "weight" given to each criterion is defined according to the features of the person. The solution is based on Bayesian network (BN) and analytic hierarchy process (AHP) method, the chart of the BN and the probabilities associated with nodes are designed to convert the knowledge of the specialists on the choice of an alternative.

In Ref. [23], the author presents a decision model to determine weights for the application, using a multi-attribute decision-making model based on Bayesian networks. Critical technique, dasiaBayesian networkspsila, is used to determine values for the weights, which combined prior information (other expertspsila knowledge, or numerical simulation, etc.) with expertspsila knowledge.

According to Ref. [24], "the weight in technique for order preference by similarity ideal solution (TOPSIS) is given by experts or decision makers. The value of weight would be influenced by expertspsila subjective judgments. A slight difference in value of weights may result in diversity of order of alternatives. In this chapter, a Bayesian method for the decision of weight for Multi-attribute decision-making model with interval data is introduced. The value of weight is decided by a priori information (other expertspsila knowledge, or numerical simulation, etc.) and experts' knowledge (or decision makerspsila experience/preference)." This paper is an example of the hybrid solution, using TOPSIS and BN in MADM.

To develop this chapter, a thorough literature survey on TOPSIS either standalone or hybridized with other heuristics/machine learning models was done. Papers like Refs. [25–30] show different types of use of TOPSIS as heuristic for decision making in the most diverse areas. Though, it is currently a hot research topic in the academic community; however, some gaps need attention which include the lack of studies using a heuristic, based on multicriteria analysis, using data collected, testing implementations on real devices, implementation of these heuristic in open platforms, mounting a consolidated database from simulation scenarios, using the TOPSIS method from a weight vector based on simulation tests, not experts, and comparison of different technologies that are already consolidated in the market.

Thus, the proposal discussed in this chapter contemplates the highlighted gaps by presenting a strategy for providing service to select the access technology for iTV environment. Therefore, the service provider can analyze the best technology to be used in a real scenario. For this, models are used for decision making based on Bayesian networks and TOPSIS.

3. Models for multicriteria decision making

When there are conflicting aims that may omit optimal solutions, decision making comes into picture as it can lead to a good solution. Multicriteria methods become important as they support decision making. According to Ref. [31], decision making can be simply described as an effort to solve the dilemma of conflicting goals. In problems concerning decision making, a decision maker usually assists in the process by listing several important criteria and analytical methods may be employed to aid in such decisions. There are two analytical approaches: American and European.

The North American approach is mainly represented by analytic hierarchy process (AHP) developed by Thomas Lorie Saaty. The European approach has a wider range of multicriteria decision methods, such as TOPSIS, elimination and choice translating reality (ELECTRE), measuring attractiveness by a categorical-based evaluation technique (MACBETH), among others [24].

From an extensive bibliographical survey in the area of decision making, TOPSIS was chosen due to its easy implementation, good behavior in mathematical tests performed, and solutions to be widespread in several areas, as in Refs. [24, 32–34].

Thus, studies were conducted with a view to decision making based on two components: (a) computational intelligence based on Bayesian networks; (b) multicriteria analysis based on TOPSIS.

4. Tests

Once the models that would be used were selected, a typical scenario was set for transmission of digital content, and a server was configured to respond to the user requests, simulating an iTV service infrastructure. Thus, characterization of the load of a typical digital TV was obtained. **Figure 1** shows the assembled infrastructure, with a transmission layer, responsible for transmitting the television programs for broadcast and interactive applications.

The application is received and executed in the user layer, which has a TV with a set-top box connected and access technology for a return channel. The infrastructure of the return channel is represented in the layer service provider and can be wired and wireless, leaving it to the provider to decide which technology is to be employed.

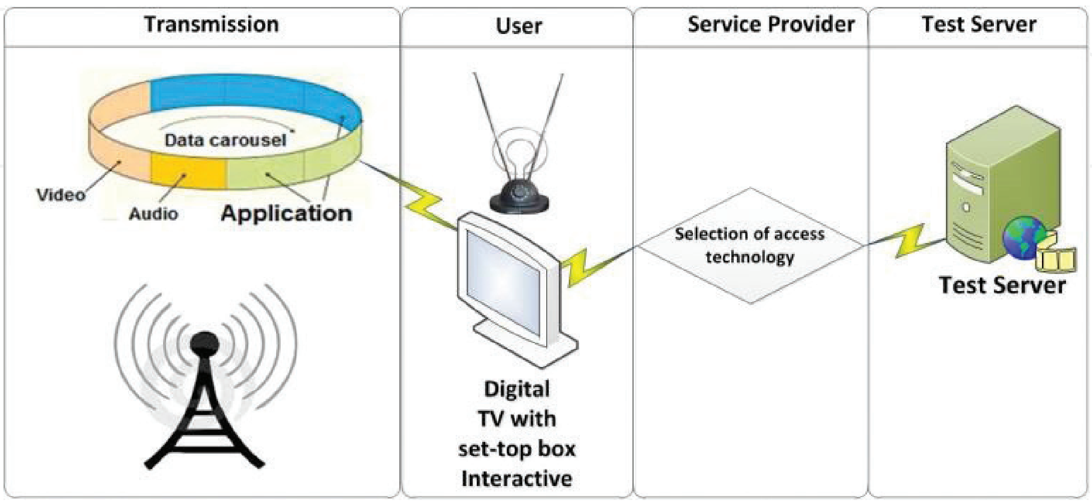

Figure 1. Scenario test the app of digital TV.

http://dx.doi.org/10.5772/intechopen.69615

The layer of the test server is responsible for responding to requests from tests, with only the application server, which has the function of helping in the measurement criteria used for decision making.

The assembly of the aforementioned scenario was based on extracting measures of a typical network of digital TV. The application used in these tests was developed by the research group of this article, and is called DTV-Educ 2.0 [35].

The purpose of this application, a chat conversation, is to make it available for regular television program, so that a student who is watching television can make classroom questions in real time or even conduct group work with other students.

Figure 2 shows a screenshot of the developed application running on OpenGinga (Ginga emulator platform) during a conversation. It presents the history of messages exchanged between participants in the chat during a television program.

4.1. Characterization of load application

To characterize the load application in the network, tests were performed where two real users, for 10 min, exchanged messages via the chat provided by the application.

All application information was recorded during the conversation via a spy program network, and **Table 1** summarizes the measured statistical results of this application.

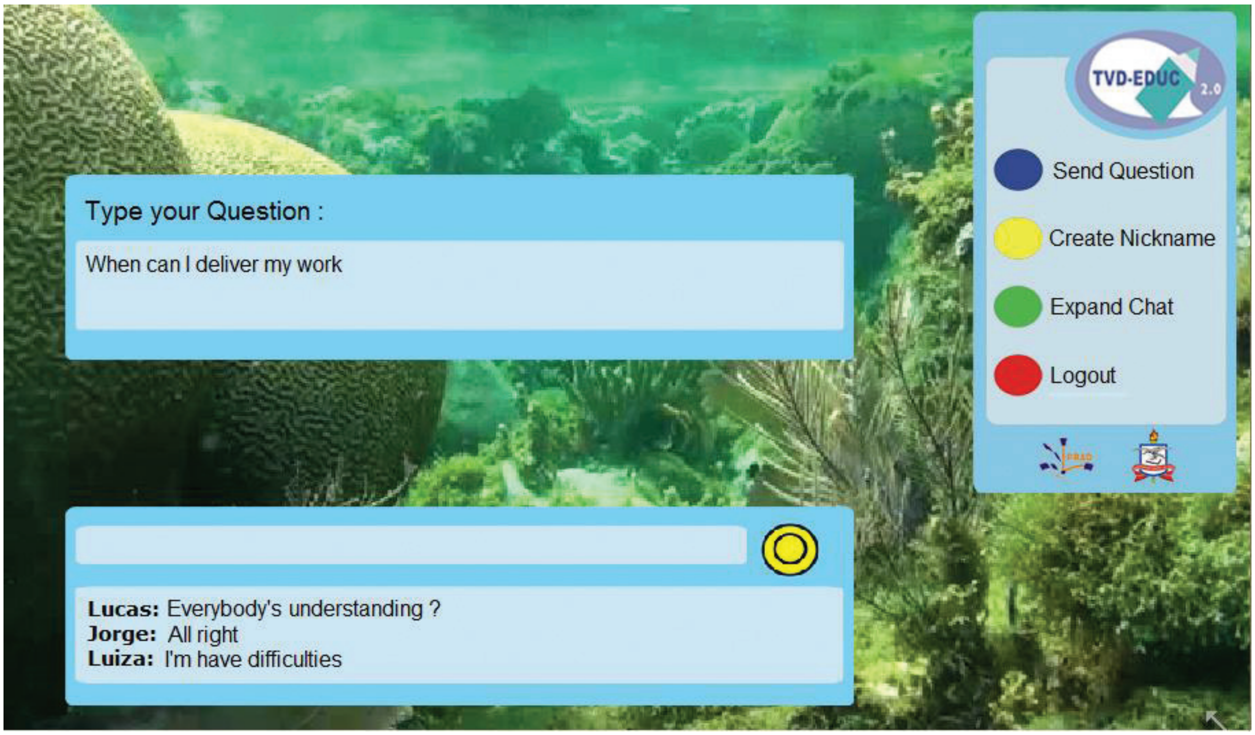

Figure 2. Application DTV-Educ 2.0 during a chat.

The measured data in **Table 1** were used for configuring the application in a simulation scenario. It is noteworthy that this application when compared with other types of traditional applications does not occupy the network much, because its traffic is only in plain text that is typed by users. In general, the applications used in digital TV environment present this behavior.

From the characterization of the DTV load application, other parameters that would be inserted in the simulation environment were set.

4.2. Definition of applications and parameters

After characterization of load application, it was necessary to conduct a research on flow commonly used on the Internet. The idea is to make the environment of a user utilizing an interactive application in as real scenario as possible.

Therefore, three streams that were used in simulation tests were defined: (i) application of video (video conferencing), (ii) application of voice over IP (VoIP), and (iii) typical application of digital TV (DTV-Educ 2.0). These three applications aimed to model traffic used by typical customers who use the Internet, and the first two were taken from Ref. [36].

The probability of some configuration parameters within digital TV application was obtained (from empirical studies) to characterize the traffic load and was fed as input to the simulator. The specification of the traffic load for the application DTV-Educ 2.0 is found in **Table 2**: type of HTTP, page interarrival time, the properties of pages loaded, and the type of service.

The configurable parameters for video traffic (**Table 3**) are the values of packet arrival time (frame interarrival time), expressed by a constant value, and package size (frame size), which

Parameter	Value
Packets transmitted	575
Average packet per second	1.016
Average size of package	59.927 bytes
Average throughput	60.898 bytes/s

Table 1. Values DTV-EDUC 2.0.

Configuration parameter	Value
HTTP specification	HTTP 1.1
Page interarrival time (s)	Weibull (0.30419, 0.1139)
Page properties	Lognormal (4.2996, 0.25489)
Type of service	Best effort (0)

Table 2. Parameters for digital TV Application.

http://dx.doi.org/10.5772/intechopen.69615

is a random variable with exponential distribution. The values assigned in these two variables generate a video application rate of 1.5 Mbps to each customer. The parameter type of service is also configured and represents that the priority will be given to the application on the network, which is the best effort type.

The configuration of the VoIP application is presented in **Table 4**. The times of silence and speech used to model the voice application parameters are represented by talk spurt and silence length. The parameters such as encoder scheme and voice frame per packet, characterize, respectively, the type of encoder used in the generation of voice traffic and the number of voice frames per packet during the simulation.

According to **Table 4**, the VoIP application uses the GSM encryption and generates a rate of approximately 20 kbps. The parameter type of service is also configured and represents the priority assigned to application on the network, which is best effort type.

Thus, applications have been developed and their characteristics were modeled using the parameters configurable by the simulator.

4.3. Simulation of a scenario

The development of the simulation tests required a tool that can simulate the performance of the network. Thus, an OPNET is the name of Network Simulator modeler was opted, which is widely used as a tool for modeling telecommunications networks, and their work environment allows creating a network from a library of templates, and set parameters not only for the environment, as well as for each object that is composed, and the impacts of its variations [37].

Configuration parameter	Value
Frame interarrival time (s)	Constant (0.1)
Frame size (bytes)	Exponential (15625)
Type of service	Best effort (0)

Table 3. Parameters for video application.

Configuration parameter	Value
Silence length (s)	Exponential (0.65)
Talk spurt length (s)	Exponential (0.352)
Encoder scheme	GSM (silence)
Voice frames per packet	1
Type of service	Best effort (0)

Table 4. Parameters for voice application.

Through this software, it was possible to observe the behavior of a network based on WiMAX, with the parameters defined in the previous section. **Figure 3** shows a scenario simulator that was set up containing 32 nodes, using the three streams defined above; a WiMAX antenna communicating with a backbone, which in turn communicates with the test server; box settings of the applications, the profiles, and WiMAX antenna.

Settings were made with parameters of real devices in order to make the simulation as realistic as possible, by applying these settings in the simulator. **Table 5** shows the main settings used in the simulation.

After analyzing the data input and configuration of the simulator, simulations were performed using a simulation time of 15 min to set up each scenario.

The tests were done thoroughly from the variation in the number of users on the network (until 40 users) and the change of seed of the simulation, which meant that for the same amount of users, different values were obtained. An extensive database was generated and consolidated, containing all the measured results of simulation experiments.

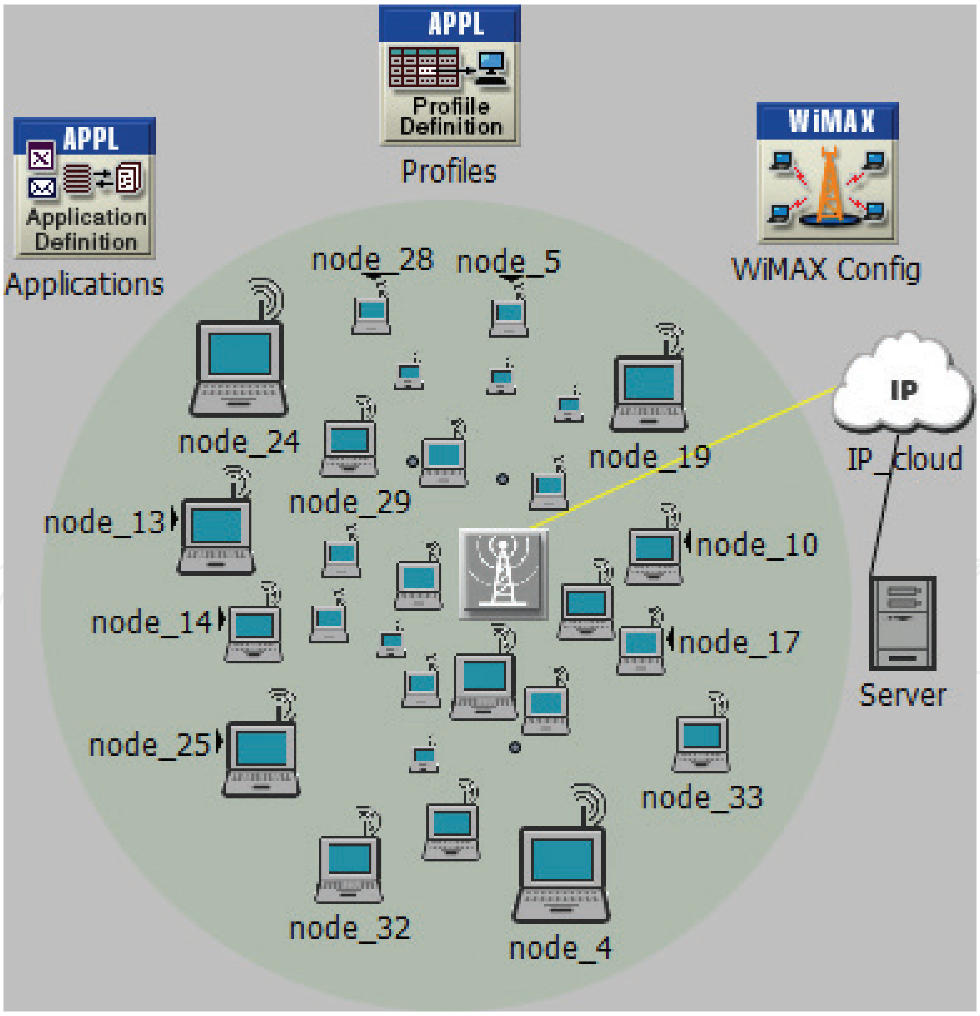

Figure 3. Scenario mounted on the OPNET simulator.

Parameter	Value
Frequency channel	5 MHz
Programming model	HATA
Antenna model	Ominidirecional
Gain transmission	1 dBm
Receive gain	1 dBm
Power transmission	0.125 dB
Length of frame	20 ms
Packet size	1024 bytes
Time of simulation	15 min

Table 5. WiMAX radio settings.

5. Generating the Bayesian network

After the organization of the database, computational intelligence model capable of extracting patterns was used. This model is Bayesian network that is used to assess the influence (weight) that each parameter has on the final result (selection of return channel).

BN is a model that codifies probabilistic relationships between variables that represent a certain domain. The BN is shaped by qualitative structure, expressing the dependencies among nodes, quantitative part (conditional probability tables of these nodes), quantifying these dependencies in probabilistic terms. To summarize, the cited components can give an efficient representation of the joint probability distribution of the set of variables for a given domain. More information can be obtained accessing Refs. [38–40].

BN was used given expertise of the group in BN area, exceptional analytical properties to expose domains, easy visualization and understanding of the relations among the variables, consisting on a crucial factor, and of great value for the representation and analysis of the domain (by the users).

For the Bayesian network, in order to establish correlations between the variables in the domain, it was necessary to define the attributes (metrics) considered for the analysis proposed in this chapter. These metrics were selected from the set of tests in the scenarios modeled in OPNET.

Thus, among the metrics provided by OPNET for analysis, seven were defined, which were used in the process of decision making. These metrics are shown in **Table 6**, as well as the description of their purpose.

From the definition of the metric (also called criteria) that would be used for decision making, a Bayesian network was generated using the search algorithm and scoring K2, widespread in the literature [41]. To this end, the application Bayesware Discoverer was employed. **Figure 4** shows the network generated from the tool, with seven nodes and their dependencies.

Metric	Description
Active connection	Total number of active TCP connections on the surrounding node.
Throughput	This statistic represents the average number of bits successfully received or transmitted by the receiver or transmitter channel per unit time, in bits per second.
Jitter	It is the value of delay variation, i.e., the difference between two delay times, measured in milliseconds.
Delay	Represents end-to-end delay of all the packets received by the WiMAX MACs of all WiMAX nodes in the network and forwarded to the higher layer.
Retransmissions	Number of TCP retransmissions on this node. Written when data is retransmitted from the TCP unacknowledged buffer.
Object response time	Specifies response time for each inlined object from the HTML page.
Data dropped	Higher layer data traffic dropped (in bits/s) by the WiMAX MAC due to data buffer overflow.

Table 6. Metrics used in the decision-making model.

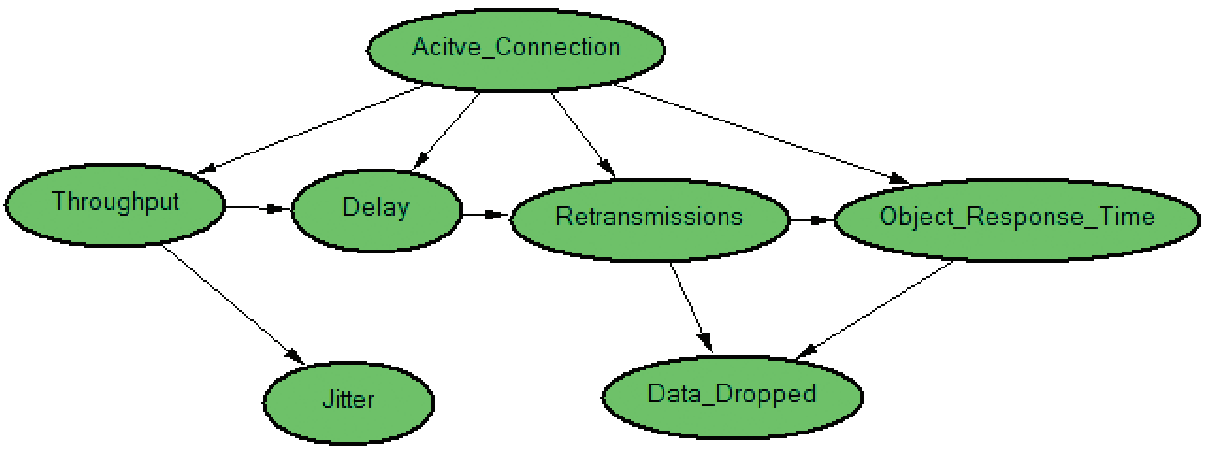

Figure 4. Bayesian network generated.

The goal of setting up the Bayesian network is to extract the weight that each criterion has measured in the simulation environment. Thus, a weight vector was generated to the application of the TOPSIS method for decision making, considering the Probability distribution shown in **Figure 5**.

We set up the conditional entropy (Eq. (1)) as a measure of the uncertainty that obtains the value of Y is known as X. If the value of $(X, Y) \sim p\ (x, y)$, then the conditional entropy $H\ (Y|X)$.

$$H(Y|X) = \sum_{x \in X} p(x) H(Y|X = x) \quad (1)$$

Guiding on the theory proposed for Bayesian networks, we could verify the impact that alterations between the states of the variable X cause on the states of the variable Y. That means, when we infer the state $Xi = 1$, for example, we determine the impact that the first X state is causing on the states of the variable Y. Then, we were able to verify the impact that each X

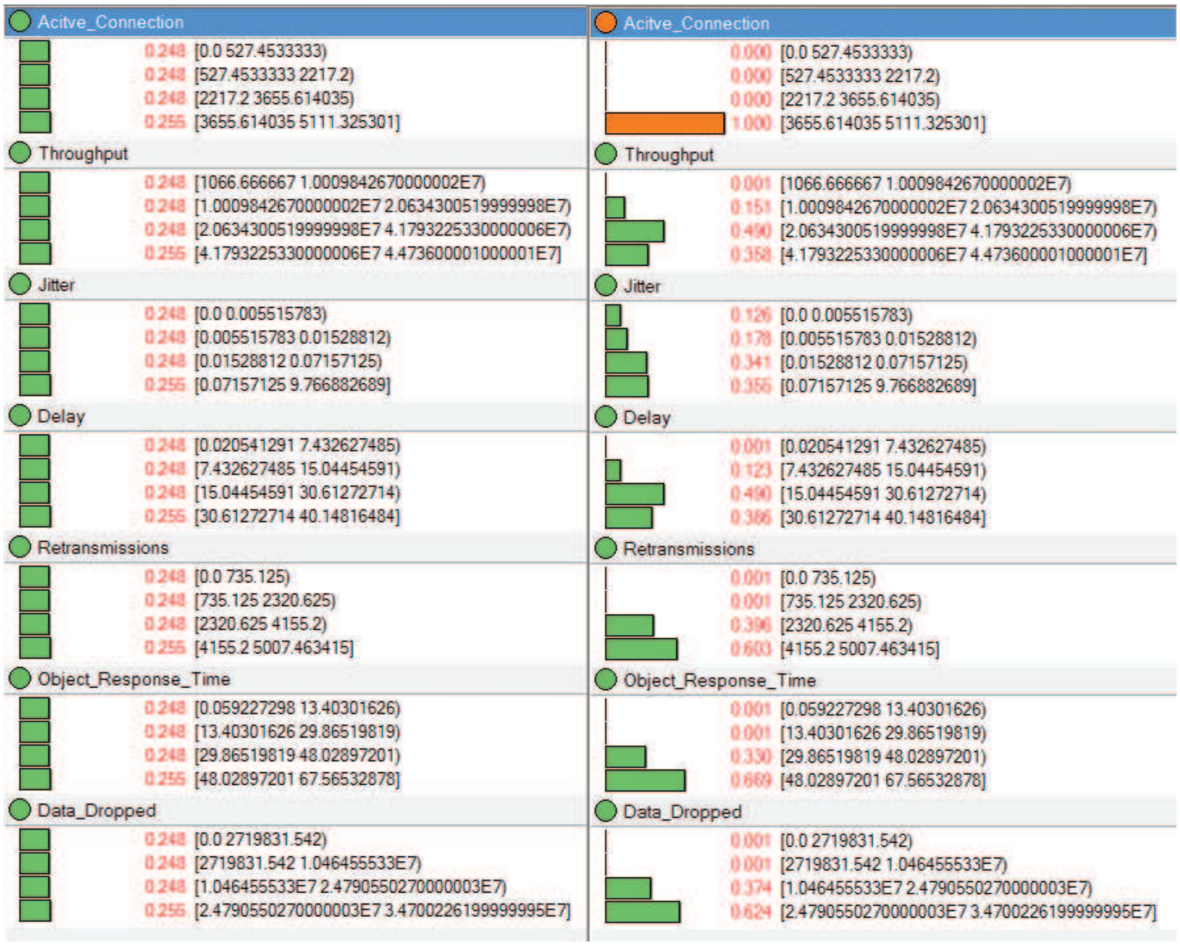

Figure 5. Probability distribution.

state was influencing on Y; in this case, the quantity of inference done in all states of the base-variables of the three defined factors was affecting the states of the other variable, which we aim to determine the weight. This influence from each state on the variable X over Y is added together, obtaining a vector of probability Vp.

Vp = [0.24 0.27 0.27 0.08 0.07 0.07]

Weight values for each criterion obtained from the Bayesian network express the influence that certain criteria have about setting the scene.

Thus, by extrapolating the fitted model and assuming that a service provider has more than one choice of access technology for a given scenario, the purpose of this chapter is to define what technology should be used.

6. Tests to evaluate the first miles

From the weights defined, real test scenarios and experiments were performed to test the proposed strategies.

In order to perform measurements in real scenarios, three access technologies were used such as PLC, WiMAX, and ADSL. The choice of these different technologies is based on the availability of resources for testing and the focus of these tests on heterogeneous networks, since the metrics analyzed should provide different values due to each technology's peculiarities.

WiMAX networks, for example, suffer interference caused by external factors such as distance between antennas and similar frequencies. PLC networks, which use electricity to transfer data, suffer interference caused by devices that operate in frequency bands similar to those used for data transmission. ADSL technology uses fixed telephony lines for data transmission and is characterized by impulsive and background noises.

Thus, scenarios were set to test the different types of technologies, as illustrated in **Figure 1**, based on four layers already defined. Then, a java applet to obtain the results of the criteria established was employed.

Based on the sampling theory, the tests performed were repeated over 50 times, to obtain an acceptable average for comparison. The average results are shown in **Table 7**.

The values shown in **Table 7** show the average of the results obtained from 1 to 40 users. These numbers represent measurements from real-world scenarios at any given time and were used in the decision-making process presented in this chapter.

From these values, a decision-making framework using TOPSIS was implemented to calculate decision making based on weights previously obtained.

7. Heuristics for decision making

After the evaluation on real scenarios of the access technologies (PLC, WiMAX and ADSL), a decision of which technology to be used follows. For the decision making, TOPSIS method is

	PLC	WiMAX	ADSL
Number of active connections	1.000	2.227	3.000
Average jitter (ms)	4.8	6.7	3.1
Average delay (ms)	16.6	21	13.5
Average throughput (kbps)	716	1436.6	6912.5
Object response time (s)	31.6	25.8	21.9
Number of data dropped	2.500	1.800	1.100
Number of retransmissions	3.000	3.700	2.200

Table 7. Results with different technologies.

http://dx.doi.org/10.5772/intechopen.69615

Country	Throughput	Jitter	Delay	Retransmissions	Object_response_time	Data_dropped	Prioritaet
ADSL	0,186154494	0,09505228146	0,1215804061	0,03354359188208	0,0331092242482394	0,02353958684215	0,9999999
WiMAX	0,138188686	0,20543557607	0,1891250762	0,05641422271077	0,0390053874705286	0,03851932392352	0,3567272
PLC	0,062051498	0,14717772614	0,1494988697	0,04574126165738	0,0477740404677792	0,05349906100490	0,3341741
Weight	0,24	0,27	0,27	0,08	0,07	0,07	(nulo)
max/mi	1	0	0	0	0	0	(nulo)

Figure 6. Results with different technologies.

applied on the results measured from the network (**Table 7**), based on the vector *V*p, which is the weight for each metric evaluated.

Using an applet, the results were compared with other applications available in the market to see the degree of certainty, all of which were proved satisfactorily.

Figure 6 shows the relative closeness to the ideal solution, ranking the alternatives in increasing order of selection.

In this case, from the use of the results of real scenarios, the best choice to service provider is the ADSL technology as it presented the best performance compared to other technologies.

If for some reason (financial, political, etc.), ADSL technology cannot be used, the WiMAX network would be selected and, as a last alternative, the PLC technology. If in case, a new evaluation is made on the networks, or another service is available with different weights, a new score table must be generated.

8. Conclusion

The papers, to serve as a basis for this chapter, surveyed for showed that several studies are being conducted in areas covered: access technologies, service provider, Digital TV, and decision support.

After analyzing the papers, gaps were found that need attention, among which are the lack of studies using a heuristic, based on multicriteria analysis, using data collected; testing implementations on real devices; implementation of these heuristic in open platforms; setting up a consolidated database from simulation scenarios; using TOPSIS from a weight vector based on simulation tests, not experts; and comparison of different technologies that are already consolidated in the market.

Thus, this chapter presents a novel strategy that considers the use of real test scenarios, drawing a comparison between more than one access technologies such as PLC, WiMAX, and ADSL. This comparison is performed by a heuristic decision making, based on the Bayesian networks and TOPSIS, which measures the best choice of the access technology.

Access providers can plan for optimizing interactive services for digital TV, using a heuristic that considers seven network performance measures active connection, jitter, delay, throughput, object response time, data dropped, and retransmissions.

As future studies, new tests will be conducted with other access technologies, for confirming the results obtained in these experiments. In addition, new techniques will be adopted to optimize the system, such as genetic algorithms and Markov decision process. Furthermore, the proposed criteria will be improved to obtain other measures for network performance.

Author details

Marcos César da Rocha Seruffo[1]*, Ádamo Lima de Santana[1], Carlos Renato Lisboa Francês[1] and Nandamudi Lankalapalli Vijaykumar[2]

*Address all correspondence to: marcos.seruffo@gmail.com

1 Federal University of Pará, Belém, Pará, Brazil

2 National Institute for Space Research (INPE), São José dos Campos, São Paulo, Brazil

References

[1] Brazilian Institute of Geography and Statistics (IBGE). National Survey by Household Sample [Internet]. 2009. Available from: <http://www.ibge.gov.br/home/estatistica/populacao/trabalhoerendimento/pnad2009/default.shtm> [Accessed: January 31 2017]

[2] Montez C, Becker V. Interactive Digital TV: Concepts, Challenges and Prospects for Brazil. UFSC Publishing company, Second Edition; 2005

[3] Prado GM, Zorzo SD. Interactive service provider architecture for interactive digital television systems. In: 2010 International Conference on Computer Information Systems and Industrial Management Applications (CISIM); 2010

[4] Costanzo BP, Neto JA. Analysis of the Brazilian digital TV system (BDTVS) and signal-converting devices. In: Portland International Center for Management of Engineering and Technology (PICMET). Annals; 2007. pp. 1830-1838

[5] Xiao Y, et al. Internet protocol television (IPTV): The killer application for the next-generation internet. IEEE Communications Magazine. 2007;**45**(11):126-134

[6] Dutta-roy A. Bring home the internet. Journal IEEE Spectrum. 2012;**39**(12):32-38

[7] Budri AK, et al. WiMAX simulation models for return channel in digital television systems. In: International Telecommunications Symposium. Annals; Fortaleza. Vol. 3; 2006. pp. 688-693

[8] Polo EI, et al. PLC as a return channel for interactive digital TV. In: International Conference on Communications and Networking in China. Annals; Shangai, China; 2007. pp. 1-5

[9] Campista MEM, et al. The ad hoc return channel: A low-cost solution for Brazilian interactive digital TV. IEEE Communications Magazine. 2007;**45**(1):136-143

[10] Nasser N. A Theoretical approach for service provider decision in heterogeneous wireless networks. In: IEEE Communications Society Subject Matter Experts for Publication in the IEEE CCNC 2016 Proceedings; 2016

[11] Hideyuki K, et al. Combined adaptive congestion control method for communication-broadcasting integrated services. In: Global Telecommunications Conference. Annals; 2006. p. 1

[12] Hideyuki K, et al. Access control method based on sample monitoring for volatile traffic in interactive TV services. In: Global Telecommunications Conference. Annals; 2008. pp. 16

[13] Habiba U, Asghar S. A survey on multi-criteria decision making approaches. In: International Conference on Emerging Technologies ICET 2009; 2009. Pp. 321-325

[14] Levin M. Selection of user´s connection in last-mile problem. IEEE Transaction on System, Man, and Cybernetics—Part a: Systems and Humans. 2011;**41**(2):370-374

[15] Kabat MR, Patel MK, Tripathy CR. A heuristic algorithm for core selection in multicast routing. Journal of Computer Science and Technology. 2011;**26**(6):954=961

[16] Charilas DE, et al. Application of fuzzy AHP and ELECTRE to network selection. Mobile Lightweight Wireless Systems. Lecture Notes of the Institute for Computer Sciences Social Informatics and Telecommunications Engineering. 2009;**13**:63-73

[17] Sgora A, et al. An access network selection algorithm for heterogeneous wireless environments. In: IEEE Symposium on Computers and Communications (ISCC), 2010; 2010

[18] Sgora A, et al. Network selection in a WiMAX-WiFi environment. Journal of Pervasive and Mobile Computing. 2010;**7**(5):584-594

[19] Chen Y. Fuzzy AHP-based method for project risk assessment. In: Conference on Fuzzy Systems and Knowledge Discovery (FSDK); 2010; Yantai, Shandong. Annals; 2010. pp. 1249=1253

[20] Yan G, et al. The design and application of a generic AHP evaluation system. In: 4th International Conference on Wireless Communications, Networking and Mobile Computing (WICOM); 2008; Donghua Univ., Shanghai. Annals; 2008. p. 1

[21] Chunhao L, et al. An improved ranking approach to AHP alternatives based on variable weights. In: 7th World Congress on Intelligent Control and Automation (WCICA); 2008. Annals. Jilin Univ., Changchun; 2008. pp. 8255-8260

[22] Zhe Fu, Delcroix V. Bayesian network based on the method of AHP for making decision. In: Information Technology and Artificial Intelligence Conference (ITAIC), 2011 6th IEEE Joint International; 2011

[23] Sun Xuan. A Novel Kind of Decision of Weight of Multi-attribute Decision-Making Model Based on Bayesian Networks. In: International Seminar on Business and Information Management (ISBIM 08); 2008

[24] Xuan S, Qinzhou N, Hefei X. A Bayesian method for decision of weight for MADM model with interval data. In: International Conference on Advanced Computer Control (ICACC 09); 2009

[25] Supraja S, Kousalya P. A comparative study by AHP and TOPSIS for the selection of all round excellence award. In: International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT); 2016

[26] Nag K, Helal M. A Fuzzy TOPSIS approach in multi-criteria decision making for supplier selection in a pharmaceutical distributor. In: International Conference on Industrial Engineering and Engineering Management (IEEM); 2016; IEEE; 2016

[27] Kaur S, Sehra SK, Sehra SS. A framework for software quality model selection using TOPSIS. In: IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT); 2017

[28] Larasati AA, Setyaningrum AH, Wardhani LK. Development decision support system of choosing medicine using TOPSIS method (Case Study: RSIA Tiara). In: 6th International Conference on Information and Communication Technology for The Muslim World (ICT4M); 2016

[29] Sari WP, Cahyaningsih E, Sensuse DI, Noprisson H. The welfare classification of Indonesian national civil servant using TOPSIS and k-Nearest Neighbour (KNN). In: 2016 IEEE Student Conference on Research and Development (SCOReD); 2016

[30] Loganathan J, Latchoumi TP, Janakiraman S, Parthiban L. A novel multi-criteria channel decision in co-operative cognitive radio network using E-TOPSIS. In: International Conference on Informatics and Analytics (ICIA); 2016

[31] Costa CAB. Absolute and relative evaluation problematiques: The concept of neutral level and the MCDA robot technique. In: Proceedings of the International Multicriteria Decision Making Workshop; 1991; Lieblice, Março. Annals; 1991. pp. 7-15

[32] Salehi M, Moghaddam TR. Project selection by using a Fuzzy topsis technique. World Academy of Science, Engineering and Technology. 2008;**2**(4):375-380

[33] Bankmaz B, Bojkovic Z, Bakmaz M. Network selection algorithm for heterogeneous wireless environment. In: XXVII Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PICK) 2007;2007

[34] Lo C, et al. Service selection based on fuzzy Topsis method. In: IEEE 24th International Conference on Advanced Information Networking and Applications Workshops (WAYNE), 2010; 2010

[35] Seruffo MCR, Monteiro FP, Silva CN, Jacob Junior AFL, Cardoso DL, Francês CRLC. DTV-EDUC 2.0: A case study of interactive educational application for Digital TV. In: 20th International Symposium on Digital Television; 2011

[36] Castro MC. Proposals for implementing quality of service in MPLS VPN architecture using formal specification language SDL object-oriented and performance analysis using OPNET simulator [thesis]. Dissertation submitted to the Faculty of Electrical Engineering and Computer Sciences; 2004

[37] OPNET Modeler. Available from http://www.opnet.com

[38] Chen Z. Data Mining and Uncertain Reasoning—An Integrated Approach. John Wiley Professional; 2001

[39] Korb KB, Nicholson. Bayesian Artificial Intelligence. CRC Press Publishing company, Second Edition; 2003

[40] Pearl J. Probabilistic Reasoning in Intelligent System. Morgan Kaufmann Publishing company; 1988

[41] Chen XW, Anantha G, Lin X. Improving bayesian network structure learning with mutual information-based node ordering in the K2 algorithm. In: IEEE Transactions on Knowledge and Data Engineering; 2008;**20**(5):628-640

IntechOpen