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Distributed Multihop Transparent Secondary Cognitive Radio Networks

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ABSTRACT

Evolution of wireless communication has lead to an enormous growth of the wireless system and its services. In the last two decades, the number of wireless systems and services has grown exponentially. Due to the high demand of the users of wireless systems, the availability of prime wireless spectrum has become severely limited. According to the National Telecommunications and Information Administration's (NTIA), only a little new bandwidth is available for the upcoming and emerging new wireless products and services as almost all frequency bands have been assigned. Because of this spectrum shortage the users coexisting in the same frequency band interfere with each other. To avoid this spectrum shortage and to utilize the spectrum efficiently the idea for Cognitive Radios (CR) was introduced. These devices utilize advanced radio and signal-processing technology. In CR there are new techniques used for spectrum-allocation purposes. In CR network the secondary network users should exist transparently without disturbing the primary network users. This is called transparent coexistence of the secondary network. Interference is caused due to the transparent coexistence of the secondary network towards the primary network. Hence, Interference Cancellation (IC) is done using channeling technique. In channeling the frequency will be slotted so that the secondary user will not cause interference to the primary network user. The probability distribution algorithm is proposed as the traffic between the nodes in the networks will be random. The system will be distributed system. By calculating the traffic, interference cancelation is done. Using probability distribution algorithm maximization of minimum throughput is achieved.

INTRODUCTION

Wireless technologies like Wi-Fi, Bluetooth, Wi-Max are in demand for the past two decades. Many wireless technologies uses the Industrial, Scientific and Medical (ISM) band. There is a constant growth in the number of devices that function at the ISM band. Federal Communications Commission (FCC) says that the utilization efficiency of the spectrum can be as low as 15% on average in a survey. Some spectrum measurement campaigns have indicated that the actual occupancy of most licensed frequency bands is quite low. The government regulators have introduced spectrum allocation policies. Due to these policies and because of the exponential growth in the wireless communication services, scarcity of the spectrum occurred (Hou, Y.T., Y. Shi and H.D. Sherali, 2008). To overcome this spectrum scarcity a novel technology which allows open spectrum sharing was introduced. This technology is called Cognitive Radio technology. CR is an emerging technology which shares the idea of sharing the spectrum dynamically. This acts as a solution to the spectrum scarcity caused by the growth in wireless communication systems. Cognitive radio network plays an important role in achieving high bandwidth utilization reducing the spectrum scarcity (Gao, F., *et al*., 2010).

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Cognitive radio is an intelligent software radio device. . In CR network, the licensed band users are called primary users. These primary users are given higher priority in the network. Cognitive radio utilizes the spectrum in a resourceful way by enabling the unlicensed that is the secondary users to establish a communication link in licensed spectrum with a condition that it does not cause any interference to the licensee that is the primary user and without affecting the quality of service as the communication between the licensed users takes place. (Geirhofer, S, *et al*., 2007). In order to achieve this, the secondary users need to exist transparently without disturbing the primary users. To stay transparent a secondary user should learn the behavior of the primary users.

II. Methodology:

In the proposed system 30 users are considered. Among them 15 users will be primary users and 15 users will be secondary users. The nodes used for transmitting and receiving are mobile or distributed nodes and of Multiple Input Multiple Output (MIMO) type (Choi, L.U and R D. Murch, 2004). Both the users act in different frequency ranges. The secondary users tries to communicate some other secondary node and if the node is not in range then the secondary network users communicates through the primary network by frequency hopping. If the primary nodes are communicating then interference occurs.

The secondary network users should exist transparently without disturbing the primary network users. This is called transparent coexistence of the secondary network. Transparent coexistence of the secondary network users is achieved by learning the behavior of the primary network users. The interference caused is removed. IC is done by channeling technique (Yuan, X *et al*., 2013). When the secondary network user tries to use the primary network when the primary users are in contact interference occurs. This interference should be avoided for high throughput (Bakr, O., *et al*., 2009). Interference that occurs is of two types:

- Internetwork Interference
- Intranetwork Interference

In channeling the frequency will be slotted so that the secondary user will not cause interference to the primary network user. The probability distribution algorithm is proposed as the traffic between the nodes in the networks will be random. By calculating the traffic, IC is done. Using probability distribution algorithm maximization of minimum throughput is achieved.

In Fig. 1, the 4 nodes are considered. Among the four nodes 2 of the nodes (Node 1 and Node 2) are primary networks and 2 other nodes (Node A and Node B) are secondary networks. The two networks act in different frequency range. The primary network acts at a range of 2.4GHz - 2.4835GHz range. The secondary network acts at a range of 433MHz - 473MHz represents the block diagram of the proposed system. The use of different frequencies increases the number of users. Node 1 and Node 2 communicate at 2.4GHz and Node A and Node B communicate at 433.9MHz. The nodes are made mobile and this causes high interference. This is cancelled by channeling where the frequencies are slotted.

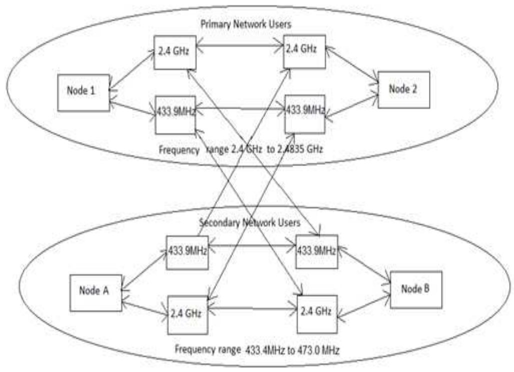

Fig. 1: Block diagram of the proposed system

Multi-hop cognitive radio technique occurs when the data is transmitted from one secondary node to another which is out of range via primary node. At that time the primary node which is of MIMO antenna switches itself to the secondary node frequency and transmits the data. Wireless MIMO systems with multiple antennas employed at both the transmitter and receiver have gained attention because of their promising improvement in terms of performance and bandwidth efficiency (Goldsmith, S.A., *et al*., 2009).

High data loss occurs as the nodes are mobile in the distributed system. In order to avoid this problem, a technique called probability distribution algorithm is introduced. In probability distribution algorithm, the random traffic between the primary network users are analyzed. The nearby nodes behaviors are learnt by the secondary node. The probability of the traffic in the neighboring nodes is studied by the node that tries to transmit data. When the traffic is free then the secondary node establishes the connection. If there is traffic then the secondary node searches for other nodes. Thus the data transmission occurs in this CR network.

III. Probability Distribution Algorithm In Cr Network:

In the existing system the nodes that are considered in the primary and secondary network are of fixed and centralized manner. Transparent coexistence of the system is achieved. Interweaving paradigm is used. The Fig. 2 represents the existing system.

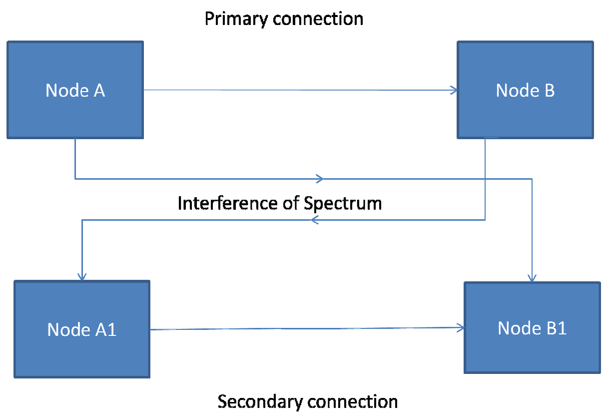

Fig. 2: Connection between primary and secondary network nodes

IC is done in by using learning the behaviour of the primary system. Challenges like

- Channelling/time slot interference
- Internetwork Interference
- Intranetwork Interference.

These challenges can be solved by considering certain properties like:

- Channel State Information with high accuracy
- Fixing time slots for traffic between the primary and secondary nodes
- Making the nodes fixed and static

In a centralized system:

- One node or router is responsible for dividing the allocated spectrum channels for different users
- This node or router should be informed about the traffic between the nodes according to the demand of the users periodically
- This responsible node or router head should be informed about the network topology. If there are any changes in the topology it should be informed to the node head periodically
- The node or router head should be periodically informed about the link quality
- The node head maintains the information about all the other nodes. Hence the information gets larger as the network grows and it gets more complex to maintain the network.

This reduces the scalability of the system. This becomes the drawback of the centralized system. In the proposed system the nodes were made random (i.e.), the nodes will be mobile nodes. The considered system is of distributed system. In a distributed system:

- Every node should be given information about the conditions of the neighborhood nodes.
- If any two nodes decides to communicate by using a channel, all the neighbor nodes should be informed about the communication.
- By informing such, it assumes that no other nodes will interfere with their communication reducing data loss.
- Every individual node should have the memory capacity which will be able to store an amount of information.
- Each nodes should be able to store large number of messages for the functioning of the algorithm as it exchanges
- The scalability of the network in this system is high

A. Probability Distribution Algorithm:

A probability distribution is used to calculate the possible outcomes of any random experiment or survey or procedure. The probability distribution basically is of two types: multivariate and univariate. This paper shares the univariate probability distribution method. Among univariate probability distribution methods, binomial distribution is used. Discrete binomial distribution is used because the number of outcomes are countable. Generally, if there are two possible outcomes i.e, success/failure in *n* independent trials, then the probability is

$$X \text{ (successes) } = \binom{n}{X} p^{X} (1-p)^{n-X} \tag{1}$$

where,
n is number of trials
X is success of out of n trials
p is probability of success
1-p is probability of failure

Using this binomial probability distribution method the traffic between the communicating nodes will be calculated. Based on the possible outcomes of the traffic, the data will be transmitted between the secondary and the primary network nodes. Only if there is no traffic the communication will be established. If not, the data from the secondary network node to primary node will be dropped. This avoids interference.

B. Algorithm:

Step1: Start the program

Step2: Initialize the nodes by fixing the number of nodes, type of antenna used, type of routing protocol and plotting circumference

Step3: Frequency is allocated for the MIMO antennas.

Step4: Positioning and plotting the nodes

Step5: Base Bandwidth allocation for primary and secondary nodes

- Primary network range- 2.4GHz - 2.485GHz
- Secondary network range- 433.4MHz - 473MHz

Step6: Setting time for node movement to move and setting the destination

Step7: Traffic is created for 30 nodes

Step8: Probability distribution algorithm is applied

Step9: When traffic is considered the starting time and ending time of the traffic is considered.

Step10: If the starting time of the transmission in the source is less than the ending time of the transmission at the destination then the connection will be terminated

Step11: Else the traffic of 10 nodes are learnt. If the traffic is free in any node then establish connection

Stpe12: Else check for closely available nodes

Step13: If there is traffic in the nodes then drop the packet

Step14: Else if there is free traffic in any node establish connection for the secondary user with the primary user.

Step15: Stop

C. Probability Distribution Flowchart:

The process of simulation is explained in the flowchart discussed below in fig. 3. The nodes, antennas are initialized initially. Frequency for each nodes will be allocated. Nodes are positioned. When the nodes are positioned traffic is applied. The probability distribution algorithm is applied.

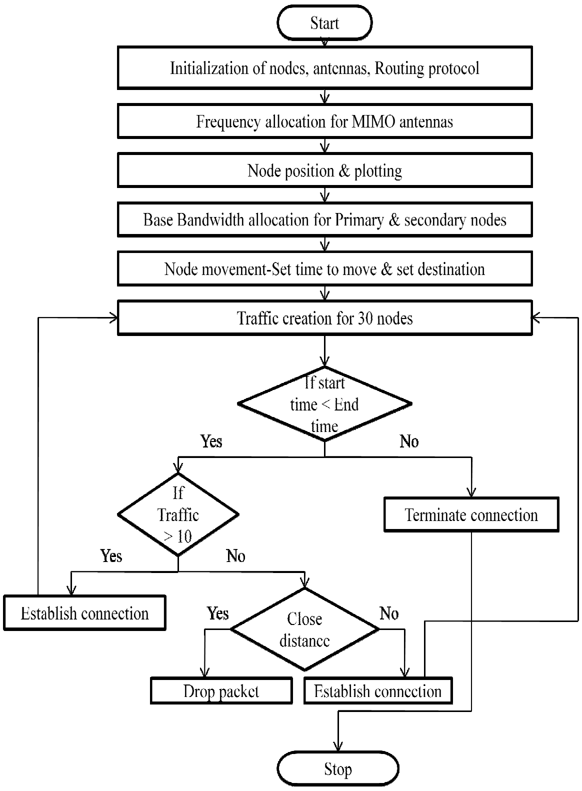

Fig. 3: Flowchart for probability distribution algorithm

IV. Result Analysis:

In the existing system, the nodes are fixed nodes. Primary nodes and secondary nodes are differentiated with colour of the nodes. 15 primary nodes and 15 secondary nodes are considered for the analysis of the parameters such as

- Throughput of the system
- Data drop while transmission
- Bit Error Rate (BER) of the transmission

Simulation and analysis is done using Network Simulator tool-NS2.

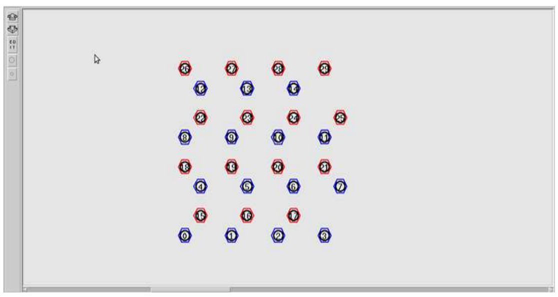

Fig. 4: Fixing nodes for the existing system

Fig.4 represents the simulation. After fixing the nodes, traffic is applied under 4 conditions:

- Traffic between two primary nodes
- Traffic between two secondary nodes
- Traffic between two primary nodes which are not in range with each other but transmits/receives data through a secondary node
- Traffic between two secondary nodes which are not in range with each other but transmits/receives data through a primary node. Fig. 4 represents the fixing nodes of the existing system.

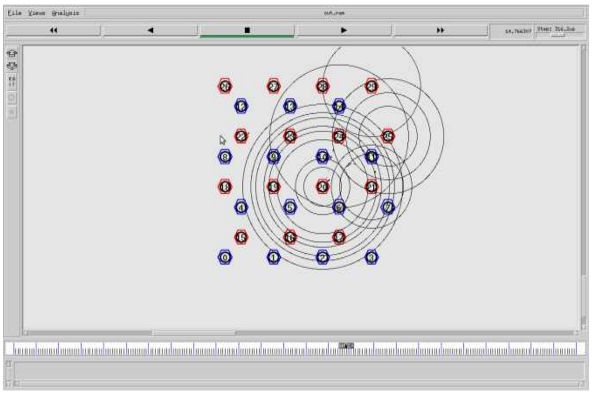

Fig. 5: Traffic between fixed nodes in existing system

The traffic between nodes is shown in Fig. 5. The traffic is applied and transmission of data occurs. Intra as well as inter network transmission is applied. The overall transmission is calculated for 24mS.

Using this centralized system:

- Throughput of the system
- Bit Error Rate (BER) of the transmission
- Data drop count while transmission are calculated and analysed (Bazaraa, M.S., *et al.*, 2010).

In the proposed system simulation the nodes are made mobile and the system is of distributed manner. When the nodes are mobile more interference occurs. This is cancelled using channeling technique.

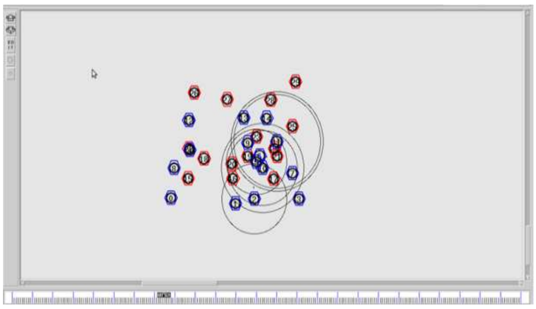

Fig. 6: Traffic between mobile nodes in proposed system

Fig. 6 represents the mobile nodes and traffic among both the primary and secondary network nodes.

- Throughput Analysis

Throughput of the system is calculated between time (ms) and data (Kb/s). Throughput is calculated for both the fixed and mobile nodes. Throughput is calculated using the ratio between the total number of the transmitted bytes to the total transmission time.

$$\text{Throughput} = \frac{\textit{Number of bytes received}}{\textit{Total transmission time}} \quad (2)$$

In the fig. 7 the throughput of the fixed node is calculated. The throughput obtained for the fixed node transmission at 24ms time period.

- Throughput for the existing system - 400 Kb/s
- Throughput for the proposed system - 750 Kb/s

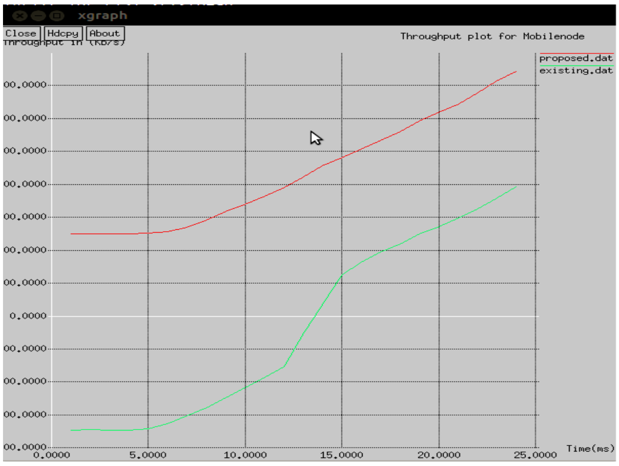

Fig. 7: Throughput analysis

Table 1: Comparison for throughput

Node status	Throughput Data$\times 10^3$(Kb/s)
Fixed Nodes (Existing)	400
Mobile Nodes (Proposed)	750

Table 1 represents the comparison made between the existing and the proposed system. In the proposed system, the throughput is improved because of the introduction of the probability distribution system.

- Data Drop Count Analysis

Data drop count is defined as the ratio between the number of bytes sent to the destination to number of bytes received at the destination while transmission.

$$\text{Data drop}=\frac{\textit{Number of bytes sent}}{\textit{Number of bytes received}} \tag{3}$$

The data drop is calculated at the end of 24ms. The data drop is calculated between the data dropped and time (ms). The data drop is calculated by considering the data about the transmission which is stored in the back end of the simulator. This can be calculated using the trace file.

The trace file can be linked to the tcl file by means of an awk file. In the awk file the drop messages which consist of both the data and acknowledgement drop are calculated together.

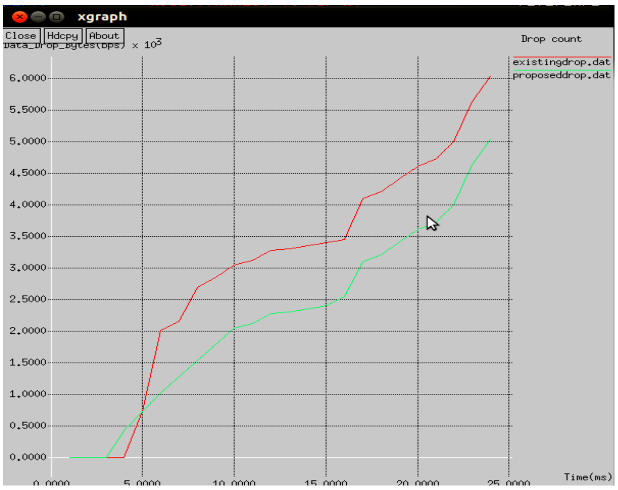

Fig. 8: Data drop count analysis

Fig. 8 represents the data drop count during transmission. The data drop count is calculated between data drop (bytes/s) and time (ms).

Data drop count for:

Australian Journal of Basic and Applied Sciences, 10(1) January 2016, Pages: 314-322

- The fixed nodes the data drop count is 6×10^3(bytes/s)
- The mobile node using probability distribution algorithm is 5×10^3(bytes/s)

Table 2: Comparison for data drop count

Node status	Drop count $\times 10^3$(bytes/s)
Fixed Nodes (Existing)	6
Mobile Nodes (Proposed)	5

Table 2 represents the comparison made between the data drop count of the existing and the proposed system. In the proposed system, the data drop is reduced because of the introduction of the probability distribution system.

- BER Analysis

In a digital transmission, the number of bit errors is the number of received bits of data stream over a communication channel that have been altered due to noise, interference, distortion or bit synchronization errors. The BER is the number of bit errors per unit time.

$$\text{BER}=\frac{\text{The number of bit errors}}{\text{Total number of transferred bits during a studied interval}} \quad (4)$$

The BER is calculated at the end of 24ms. The BER is calculated between the errored bit (dB) and time (ms). Fig.9 represents the BER during transmission. The BER is calculated between data drop (dB) and time (ms).

BER for:

- The fixed nodes BER is 185×10^{-3} (dB)
- The mobile node using probability distribution algorithm is 165×10^{-3} (dB)

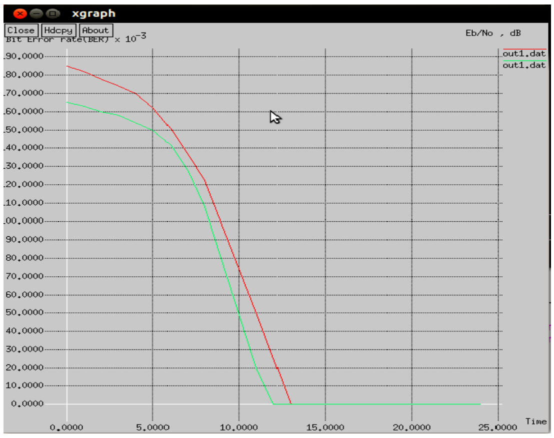

Fig. 9: BER analysis

Table 3 represents the comparison made between the BER of the existing and the proposed system. In the proposed system, the BER is reduced because of the introduction of the probability distribution system.

Table 3: Comparison for BER

Node status	Bit Error Rate (BER) $\times 10^{-3}$ (bps)
Fixed Nodes (Existing)	185
Mobile Nodes (Proposed)	165

Conclusion:

In the proposed system different set of frequencies are used so that the number of users can be improved under each network. Interference cancelation is done by the secondary network by learning the behavior of the primary network. The cancelation of the interference improves the successful transmission. Using probability distribution algorithm the spectrum access sharing is improved. Throughput in the proposed system is maximized when compared to the existing system. BER is reduced during the transmission. Data drop count is also reduced as calculated.

Thus, the proposed cognitive radio network scheme is highly efficient as the secondary network users achieve transparent coexistence of the primary networks. In real time, distributed system will add additional complexity on information update and algorithm execution.

Australian Journal of Basic and Applied Sciences, 10(1) January 2016, Pages: 314-322

REFERENCES

Akyildiz, I.F., W.-Y. Lee, M.C. Vuran and S. Mohanty, 2006. ‘Next generation/ dynamic spectrum access/cognitive radio wireless networks: A survey’, Comput. Netw., 50(13): 2127-2159.

Hou, Y.T., Y. Shi and H.D. Sherali, 2008.‘Spectrum sharing for multi-hop networking with cognitive radios’, IEEE J. Sel. Areas Commun., 26(1): 146-155.

Geirhofer, S, *et al*., 2007. ‘Dynamic spectrum access in the time domain: Modeling and exploiting white space,’ IEEE Commun. Mag., 45(5): 66-72.

Gao, F., R. Zhang, Y.-C. Liang and X. Wang, 2010. ‘Design of learning-based MIMO cognitive radio systems’, IEEE Trans. Veh. Technol., 59(4): 1707-1720.

Choi, L.U and R D. Murch, 2004. ‘A transmit pre processing technique for multiuser MIMO systems using a decomposition approach’, IEEE Trans. Wireless Commun., 3(1): 20-24.

Yuan, X *et al*., 2013. ‘Beyond interference avoidance: On transparent coexistence for multi-hop secondary CR networks’, in Proc. IEEE SECON, New Orleans, LA, USA, 24-27: 398-405.

Bakr, O., *et al*., 2009. ’Multiantenna interference cancellation techniques for cognitive radio applications’, in Proc. IEEE WCNC, Budapest, Hungary.

Goldsmith, S.A., I. Jafar, Maric and S. Srinivasa, 2009. ‘Breaking spectrum gridlock with cognitive radios: An information theoretic perspective’, Proc. IEEE, 97(5): 894-914.

Kanaris, L., Eindhoven, A. Kokkinis, A. Liotta, M. Raspopoulos, 2013. ‘A binomial distribution approach for the evaluation of indoor positioning systems’ in IEEE Conference in Telecommunications (ICT), 20th International Conference, pp: 1-4.

Bazaraa, M.S., J.J. Jarvis and H.D. Sherali, 2010. ‘Linear Programming and Network Flows’, 4th ed. Hoboken, NJ, USA: Wiley.