In the contemporary world, myriad manifestations have arisen from the field of Wireless Communications, establishing its ubiquity in all dimensions of human interaction. Its manifold complexity, due to the ever-evolving technological possibilities, presents unique techno-commercial problems towards creating an effective and efficient ecosystem. The important issues include how to achieve maximum resource utilization, mutual benefits for all the stakeholders, and seamless integration of technology to realize the efficiencies of scale and scope. The most critical resource in this ecosystem is the ‘Spectrum’. As per Wikipedia definition, Spectrum management is the process of regulating the use of radio frequencies to promote efficient use and gain a net social benefit. Radio frequency spectrum has emerged as one of the most contested public goods in recent years. Intense demand, coupled with short supply, has rendered spectrum management and competitive allocation of related property rights now a well-researched area of public debate. Spectrum being a scarce natural resource for a country, its allocation, use, and management are of utmost importance to a nation. India is no exception to that. For that matter, this book (published in 2014) is very much a topical one given the fact that spectrum auction in India is gaining traction and becoming hugely competitive. For all those involved with the management of spectrum in India, this book is a must-read.

In the past, the auction of the spectrum has led to some adverse and unpredictable macroeconomic situations in some regions of the world. The ‘Telecom crash’ of 2001 in Europe, which has been linked to the allocation of 3G radio spectrum, is one such case. The case of 2G spectrum allocations in India in 2008, and its political ramifications later on, as well as the recently concluded 3G/4G spectrum allocations (2014–2015) and the policy lessons therefrom are also noteworthy. These events lead to an unsettling concern over the robustness and efficiency of the contemporary techniques of spectrum valuation, licensing processes, and spectrum management regimes. Thus, the prevailing situations make it imperative for a decision-maker, industry members, and academia as well, to become familiar with the conceptual issues involved in the allocation and assignment of spectrum, various auction formats and models for their valuation, and the frameworks for spectrum transitions. Here lies the relevance of the book, since it discusses all these crucial aspects in detail and their evolution over time in a structured chronological order.
The book comprises 12 chapters, and each chapter is subdivided into several subsections. The authors begin with the evolution of radio communication, and the theoretical concepts of frequency of a wave and its effect on the propagation capability, the power of transmission, and the concept of bandwidth. After building upon the basic concepts, characteristics, and challenges of radio communication, it introduces the governing bodies worldwide for implementing technology, establishing standards, and managing the resources in the wireless communications regime. The narrative is simple enough to read even for a non-technical naïve reader. The journey from the analog to various digital communication standards (from AMPS to 2, 2.5, 3, 4, & 5G) helps one understand the closely linked nature of technology evolution for voice/data transfer and the corresponding network architecture adhering to the standard. The exhibits provide a rich understanding of the complete landscape and various inter-linkages, through the graphical timeline of standards, associated technologies and their evolution, frequency bands and their usage, etc. Although the initial chapter might seem to be too detailed and full of information at times, the dilemma faced by the authors is well understood, because removing any of the information could be at the expense of breaking the chronology thereby leading to incomplete knowledge.

After an introduction to the technology of spectrum, the ‘economics’ of it is dealt with meticulously. The authors very succinctly describe how the spectrum is viewed from the perspective of economic goods. Theoretically, economic goods have been classified along two dimensions, namely excludability and rivalrousness. The concept of excludability is based on the notion that there exists a possibility of excluding an entity from using the goods. The excludability must be validated from a social standpoint, should not require excessive resources to create the conditions of exclusion, and should be made possible by existing engineering capabilities. On the other hand, the concept of rivalrousness deals with the unavailability of use of the resource for other entities, merely by having the resource being used by one entity at any given time. Keeping in mind the amount of the goods available, the time over which it is likely to be used, and the number of users, any economic good could be classified along these two parameters. Using this framework, spectrum has been categorized as being an excludable and partially rivalrous good, subject to the factors of technological constraints. The chapters also analyse an interesting situation, where a partially rivalrous good like spectrum, is treated as a common resource, and explain how an uncoordinated use of such a good leads to its over-utilization, conventionally referred to as the tragedy of the commons. Building on this rationale, the book describes how the use of auctions as a way of allocating property rights in spectrum was propounded. While addressing the resolution of the commons’ tragedy, the book compares and contrasts the regime of privatization versus the spectrum commons, and explains the related ‘trade-offs of innovation’ versus ‘the network congestion’, and ‘technological progress’ versus ‘costs of R&D’. The three approaches of spectrum management, being the exclusive rights or flexible use approach, the Commons model, and the Command and Control model, have been defined well and the summary highlights how the future would tend towards adoption of a hybrid approach rather than any one of the standalone approaches.

The chapters explaining the economic principles underlying the decisions about the spectrum management are very important from the policy formulation aspects as well as the impacts on the potential licensees of spectrum, and vendors of enabling technology and device. The factors like the specific use of the spectrum, the adoption of technology standards, the number of licensees, and the determination of administrative price while creating exclusive licensing regimes, have been analysed and their interrelatedness have been explored. The design of auctions and secondary markets turn out to be the biggest challenges for the policymakers. Under the formats of ‘first and second-price auctions’, and ‘static’ and ‘dynamic auctions’, and based on the case studies of spectrum auctions around the world, various design principles related to auction theory have been explained. The findings of the auction theory concentrate on aspects of ‘The Winner’s Curse’, ‘Collusion’, ‘Reserve Price’, and ‘Multi Unit Auctions’. The relative success of the auction method over any other form has been ascertained by the authors, especially that of ‘simultaneous ascending auction’. The chapter suggests the possibility of revenue maximization being made possible by the limited release of the spectrum, and explains the trade-offs between efficiency and technological progress that are involved. The suggestion on
the part of the government is of exercising caution and to adopt a holistic approach in auctions, and not just focus on revenue maximization alone.

The authors have very succinctly captured the pitfalls to be avoided while deciding on the factors that affect the decision-making processes of spectrum valuation. Specifically, how one may be tempted to look at either ‘the extrinsic’ (ecosystem value associated with a particular band of spectrum), or ‘the intrinsic’ (based on the technical characteristics of the spectrum, like the propagation capability) factors only, whereas the fact that estimates the actual market performance should be the guiding factor. Based on this rationale, both the ‘production function’ method and the ‘cash-flow’ method, for evaluating the spectrum value have been described, taking an Indian telecom circle as an example. It has always been known that the owner of the spectrum, which is the state, must have had an active role to play in determining how a particular band of spectrum is to be utilized, and thereby have been a direct influence on the associated technologies and the creation of ecosystems. The book argues that this command and control approach of dealing with spectrum management would not necessarily lead to positive externalities always, and that it needs to evolve into a flexible use system and should largely be left to the market forces to determine its course. The inefficiencies in the use of a large amount of spectrum, which is held by different government agencies, and a general lack of availability of the spectrum for commercial purposes, portray the limited extent to which the market potential has been harnessed. The extensive examples highlighting the adoption of new licence frameworks across the world, and different novel approaches of spectrum and resource sharing, leading to greater efficiencies in the value chain are highly informative.

Some of the portions, specifically the one dealing with ‘Spectrum Commons’, and various spectrum sharing models are more about factual information and less about concepts and the interplay between various possibilities. The authors have avoided recommending any specific model of spectrum sharing as the recommended one and have merely summarized the available options. However, on the subject of ‘net-neutrality’, which is highly talked about in the contemporary scenario, the arguments from both sides have been put forward. The provision of connectivity is treated as a ‘toll good’, which is ‘excludable’ and ‘non-rival’ in nature to a certain extent. Based on this classification a number of analytical models have been proposed, trying to establish the importance of context on the impact of net neutrality. The conflict of interest between the ‘end-user connectivity providers’ (ECPs) and the ‘content and application developers’ (CAPs), which can be due to the vertical integration happening in the ECPs, have been explained in detail. Although both sides of the arguments have been presented on ‘net-neutrality’, the following quote of Tim Berners Lee, from the book, summarizes the nature of the conflict and the importance of addressing it.

*The neutral communications medium is essential to our society. It is the basis of a fair, competitive market economy. It is the basis of democracy, by which a community should decide what to do. It is the basis of science, by which human-kind should decide what is true. Let us protect the neutrality of the net.*

The book has largely dealt with the Indian telecom scenarios in the latter part, and has traced the evolution of firm partnerships in the backdrop of the flexible spectrum regime change and done a careful study on how competition and cooperation are both harnessed innovatively for creating newer opportunities and mutual gain. The effects of these newer models and partnerships on the stakeholders in the ecosystem—namely operators, technology providers, content providers, network equipment manufacturers, and handset operators—have been explored in detail. There is a chronological study of the evolution of cellular market structure in India and the roll-out process of the spectrum licences. It also talks about how the criteria for spectrum eligibility and the limit placed on the number of operators, etc. have changed over time, in the light of newer mechanisms and technologies and the role of market itself. While the processes adopted by the government have been found to be questionable, and at times been subject to legal scrutiny, the appreciation shown towards the adoption of flexible and robust approach and the acceptance of the market as a major factor need to be mentioned as well. The discussions related to the spectrum auctions in various frequency bands in the Indian case are merely factual information in the form of past data collected from TRAI, etc., and dilutes a little the otherwise insightful content overall.
The book also touches upon the increasing trend of convergence which is seen in providing different types of broadcast communication services like FM Radio, Cable TV, DTH and the Internet services, by the same service provider. The increasing demand for spectrum in the related bands due to this effect and the management of spectrum assignment has been dealt with and explained briefly. This book is recommended for anyone willing to understand how the ‘spectrum’, although available freely to us all, has been owned over time, how it has come to be valued, and the patterns in which it is consumed. While the academia would get a bird’s eye view of different aspects of spectrum management, and may choose to evaluate and critique the current status quo, policy-makers and professionals from the industry could appreciate the complicated ecosystem better and become aware of the alternate perspectives and the Pareto-optimal future that is possible.

Debashis Saha
Professor
Indian Institute of Management Calcutta
e-mail: ds@iimcal.ac.in