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Open access wireless markets

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ABSTRACT

This paper describes an open access market for capacity. Open access means that in real-time, network capacity cannot be withheld—capacity is priced dynamically by the marginal demand during congestion. The paper offers the open access market as a means for managing growing spectrum demand and as an alternative to naked spectrum sharing. The paper describes the parameters of the open access market showing that it can be implemented using today's technology and without significant regulatory change. The paper discusses how the open access market can eliminate barriers at the service level, allowing any number of service providers to compete in response to market drivers. The paper emphasises that the spatial and temporal granularity at which capacity can be purchased, allows for smaller entities to acquire resources, which is important for new entrants testing the water and those with non-standard business plans. The paper also shows how the open access market can provide a path to achieve greater sharing and efficient trade in the future.

1. Introduction

It is widely accepted that spectrum is a highly valuable resource and that the demand for spectrum will continue to rise, as predictions such as Cisco, 2016 show. In the last decades there has been a very large academic focus on how to make more efficient and effective use of this valuable resource. Many of the solutions that have been suggested revolve around taking more dynamic approaches to spectrum allocation and assignment. These include approaches such as dynamic spectrum access, spectrum pooling, real-time spectrum trading, and a myriad of approaches to spectrum sharing, examples of which include, Buddhikot, Kolodzy, Miller, Ryan, and Evans (2005); Lehr and Crowcroft (2005), Doyle (2009), and Xiou, Chen, Han, and DaSilva, (2015).

In this paper we focus on optimising spectrum usage through focusing on capacity rather than focusing on naked spectrum. This a term coined by Hazlett (2011) and refers to frequency bands only with no infrastructure supporting it. Capacity, on the other hand, is something that exists on a network. In other words, it is the result of *coupling* the spectrum with infrastructure. While it lacks the purist attraction of working at the spectrum level because the network technology plays a role in the solution and it is therefore not technology neutral, as the paper will go on to show, there is much to be gained by focusing on capacity.

The buying and selling of capacity is well understood and is well established. In the first instance capacity is bought and sold in the form of roaming agreements. Roaming is a general term referring to the ability for a mobile network customer to automatically use all of their mobile phone services, when travelling outside the geographical coverage area of their home network, through 'visiting' another network. Roaming typically takes place when users move outside national boundaries. However national roaming exists in a number of countries. National roaming is also seen as a technique for addressing lack of capacity in rural areas. Whether national or international, the visitor networks are compensated by the home network for serving the users, usually through bilateral

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billing arrangements between the two.

Capacity is also bought and sold by mobile virtual network operators (MVNOs). In this case the mobile network operator (MNO) functions in wholesale mode and offers bulk capacity to an MVNO wishing to offer services to its own customers without the need to own a network itself. The MNO can estimate their own users needs to determine spare capacity and subsequently determine the number of MVNOs it can facilitate on its network. By mid 2015 it was estimated that there are more than 1000 MVNOs in the world.[1]

While roaming and MVNOs represent great examples of capacity being bought and sold, they have their limitations. Roaming is designed for mobile operators to support each other, in other words for 'like to support like'. In the MVNO world we see something similar. In the vast majority of cases, the MVNO offers the same services and the underlying MNO, again 'like supporting like'. The relationship between the MVNO and MNO tends to be quite static. Simple mechanisms are often used to estimate spare capacity on the MNO network, often based on average demands. The number of MVNOs that can be supported by the space capacity is then in turn based on the predicted average demands of the MVNOs. The access of the MVNO on to the MNO network is completely controlled by the MNO. The MNO-MVNO relationship is not designed for access to capacity for new and various different types of emerging service providers such as those which might result from different sectors such as health, transport, agriculture, etc. becoming increasingly digitized and calling for new types of operator. It is not designed to be open to any and all interested parties wishing to test out new wireless applications. The relationship is not designed to support access to capacity in given locations only; to support access to capacity on an as needed basis; to dynamically target underused capacity; or any mix of the above.

As the demand for spectrum increases, as machine-to-machine (M2M) and Internet-of-Things (IoT) services become more prevalent, and as many new service providers emerge it will be necessary to use capacity on the network more effectively, to accommodate more heterogeneous services, and to be open to more competition. Little attention has been paid to how capacity might be dynamically managed to better suit the demands of future communication systems. Little attention has also been paid to how capacity on a network might be opened up for usage by new entrants and different types of service providers. The purpose of this paper is to address this shortfall through presenting one accessible and highly dynamic approach to the buying and selling of capacity on what is termed an *open access market*.

The trick is to create an open access market that allows anyone with a good idea to gain access to mobile communications at competitive rates. An open access market for mobile network capacity is a market that is open to all. Indeed, the cornerstone to open access is that use of the network cannot be withheld. Just like the Internet, anyone can use it on a non-discriminatory basis. Of course, the capacity of the network is scarce, and so prices are needed to assign network resources to users. Hence an open access network adopts efficient pricing. Supply is not withheld. Price is set at the value of the marginal demand.

The open access market model is not new. Open access is the foundation of today's restructured electricity markets. Many modern wholesale electricity markets, such as those in the US, operate on this open access principle and price energy at every time and location. Pricing energy at every time and location is called *locational marginal pricing* (LMP) in the real-time market. Locational marginal pricing is a way for wholesale electric energy prices to reflect the value of electric energy at different locations, accounting for the patterns of load, generation, and the physical limits of the transmission system. LPM is a mechanism for using market-based prices for managing transmission congestion. Prices are determined by the bids/offers submitted by market participants. The charge for transmission usage is the incremental cost of the redispatch required to accommodate that transmission usage. Locational marginal prices differ by location when transmission congestion occurs – areas that have more congestion will have higher prices. If there is no transmission congestion, the charge for transmission usage is zero (except for other charges to recover portions of the embedded cost of the transmission grid, etc.). Open access markets in the electricity sector work extremely well. The high level of price transparency not only leads to efficient short-run decisions, but also provides a wealth of market information for longer-term planning including future network investments. Open access is the key force that has led to competitive wholesale electricity markets that have provided reliable electricity supply while saving consumers many tens of billions of dollars from an efficient and competitive market for electricity, as described by O'Connor, P. and O'Connell-Diaz (2015).

The purpose of this paper is to present a design for an open access capacity market that borrows ideas from the open access electricity markets, and fine-tunes them for the world of wireless communications. The main contribution of this paper, therefore, is an introduction to and a description of a practical open access market for network capacity. The paper will show it is a highly dynamic solution, which can support strong competition, involves little regulatory changes, and can work with existing technology. The attractions of the open access approach are many for the wireless world and one of the contributions of the paper is to highlight those attractions. The paper draws heavily on the Cramton and Doyle (2016) whitepaper.

The paper begins by introducing the general principles and structure of the open access capacity market in Section 2. As will be seen in that section, there is a need for both a real-time and forward components and both of these are described. The description is given without reference, in as much as possible, to any specific technology. Section 3 of the paper provides more detail of the open access market by grounding it in an LTE example and through describing how it might be implemented. Section 4 takes a step back and does an analysis of the open access market for capacity through exploring opportunities and challenges, while Section 5 concludes.

[1] http://www.fiercewireless.com/europe/report-number-mvnos-exceeds-1-000-globally (last accessed January 2017)