

# A spectrum broker service for CBRS Priority Access Licenses on Illiquid, non-realtime, secondary markets

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# Outline

- Demand
- Pricing
- Marketplace



# Demand



# Secondary markets in CBRS

- The FCC revisited rules for CBRS in 2016
- Light-touch leasing process
- To enable secondary markets for the spectrum use rights held by PAL licensees.
- No FCC oversight is required for partitioning and disaggregation
- PAL licensees are free to lease any portion of their spectrum or license outside of their PPA.

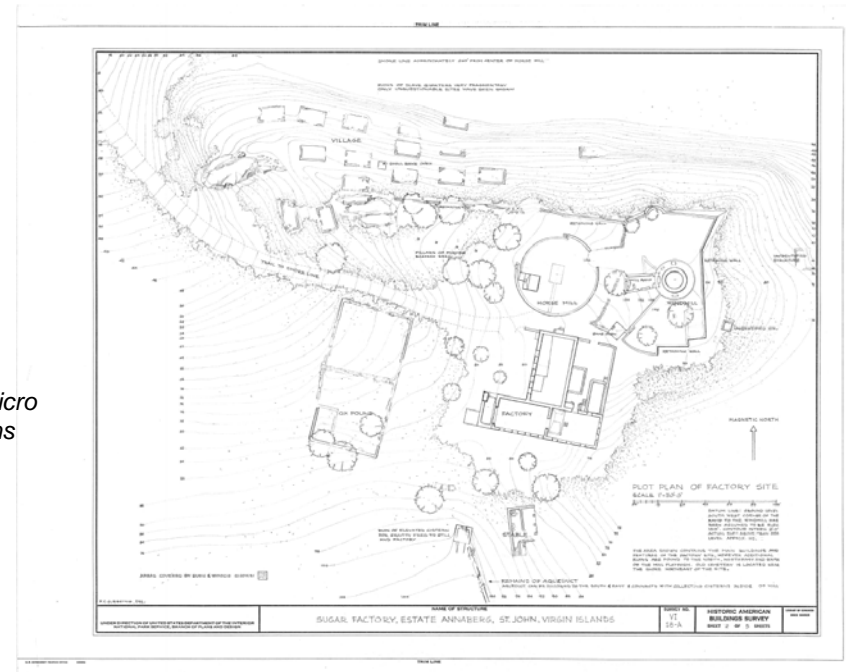
*FCC (2016) 16–55: The Second Report and Order and Order on Reconsideration finalizes rules for innovative Citizens Broadband Radio Service in the 3.5 GHz Band (3550–3700 MHz).*



# Micro-operator

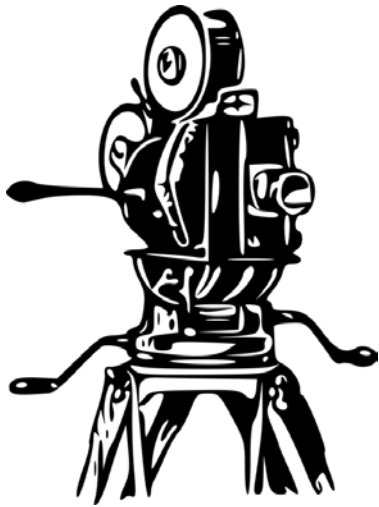
- Local small cell service in 5G
- Factories, campuses, malls, and sports arenas
- Rapid respond to local needs
- Factory of the Future

*Matinmikko, M., Latva-aho, M., Ahokangas, P., Yrjölä, S., Koivumäki, T. (2017) Micro operators to boost local service delivery in 5G. Wireless Personal Communications journal, Springer.*

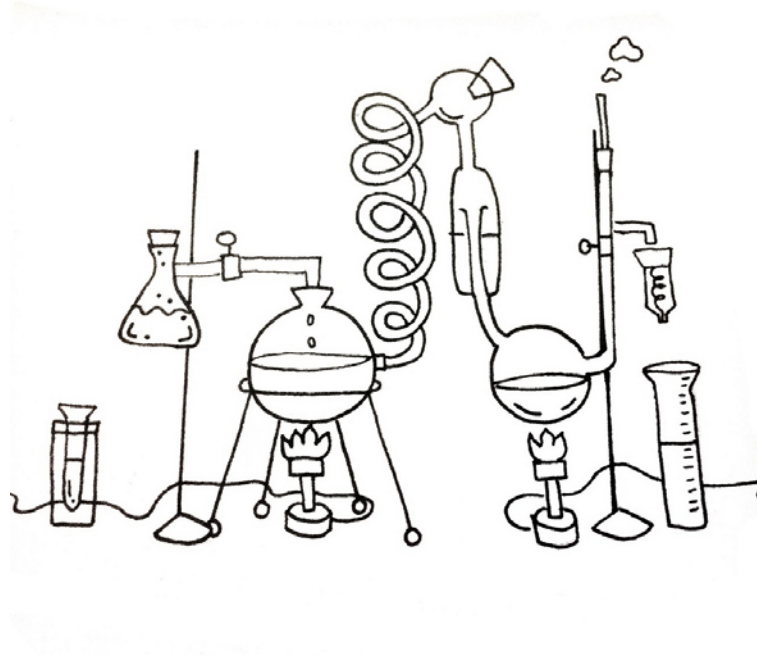




# Events



# R&D licenses



# Secondary governmental use





# Pricing



# Secondary market

- On primary spectrum market the government authorities sell long term licenses by auctions
- On real-time secondary marketplaces capacity is auctioned according to current demand
- If there is a high demand for a particular micro license, sellers can use auction instead of a buy now price.

*Toth P., Vološin M., Zoričák M., Zausinová J., Gazda V. (2017). Frequency spectrum allocation in an agent-based model of real-time spectrum secondary market. Applied Machine Intelligence and Informatics, 2017 IEEE 15th International Symposium, 000129-000136*

*Yoon, H., Hwang, J., Weiss, M. B. (2012) An analytic research on secondary-spectrum trading mechanisms based on technical and market changes. Computer Networks 56 (1), 3-19.*



# Auctions vs. Fixed pricing

- Auctions can be used to find the equilibrium price but they do not work as efficiently if there are only few buyers.
- It is reasonable to assume that the number of buyers is relatively small for secondary licenses because they are local and they benefit only few buyers

*Tonmukayakul A., Weiss M. B. (2008). A study of secondary spectrum use using agent-based computational economics. Netnomics, 9(2), 125-151.*



# Pricing model from Ficora

$\text{Fee} = C1 \cdot Cinh \cdot C6b \cdot B0 \cdot S \cdot P$ , where

$C1$  = frequency band coefficient,

$Cinh$  = population coefficient,

$C6b$  = system coefficient,

$B0$  = relative bandwidth,

$S$  = basic fee coefficient and

$P$  = basic fee.

<https://www.viestintavirasto.fi/en/spectrum/radiolicences/frequencyfees.html>



# Marketplace

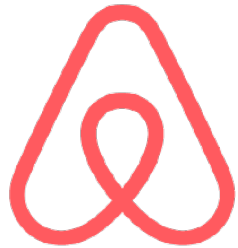




# Peer-to-peer marketplaces



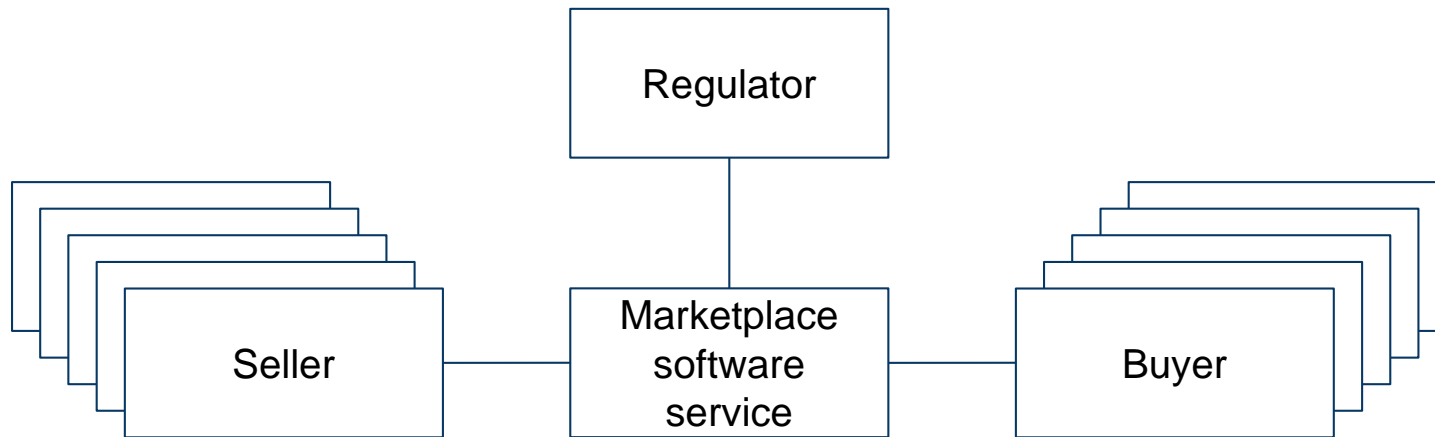
U B E R



airbnb




# Marketplace software



# Seller

- Creating sales/lease item
- Modifying sales/lease item
- Hiding sales/lease item
- Deleting sales/lease item
- Reviewing buyer
- Issuing receipt
- Managing sales/leases



The screenshot displays the Fairspectrum Seller interface. At the top, a map shows a selected area in blue. Below the map, a table lists the details of the listing:

Sale	Yes
Available from:	01.06.17
Rent	Yes
Available from:	01.06.17
Available to:	31.12.18
Frequencies:	5500-5560
Sale price factor:	110%
Rent price factor:	105%

Below the table is a button labeled "Confirm listing". To the right of the map, there are three text boxes:

- Seller draws the area that it wants to list as available
- Seller enters the detail of the listing
- The system automatically determines the base price of the requested frequencies. Price factor allows operators to change the automatic valuation

At the bottom right, there is a button labeled "Restrictions".



# Buyer

- Searching items
- Browsing items
- Purchasing item
- Leasing item
- Reviewing item
- Reviewing seller
- Payment
- Managing purchases



Buy Now	Yes
From:	01.06.17
Rent	Yes
From:	01.06.17
To:	31.12.20
Frequency range:	5000-6000
Bandwidth:	40
Number of transmitters:	50
Equipment Category:	Fixed Wireless Network

Search

Buyer draws a specific coverage area to find available licenses

Buyer chooses the dates when he needs the license

Buyer enters technical parameters to determine price, interference, etc



# Regulator

- Searching items
- Browsing items
- Hiding items
- Viewing purchase history

<b>MNO 1</b> Frequencies: 5500 - 5520 Rent only Available: 23.05.17-31.12.17 Price: 1000e per week	<input type="button" value="Lease"/> <input type="button" value="Buy"/>
<b>MNO 2</b> Frequencies: 5520 - 5540 Sale only Available: 01.06.17 Price: 100000e Buy Now	<input type="button" value="Lease"/> <input type="button" value="Buy"/>
<b>MNO 3</b> Frequencies: 5580 - 5600 Sale and Rent Available: 1.6.17-31.12.18 Price: 1200e per week 95000e Buy Now	<input type="button" value="Lease"/> <input type="button" value="Buy"/>





# Additional functionality

- Interference computation
- Automated pricing
- Interfaces to Seller ERP, Buyer ERP, and Regulator spectrum and license management system



# Future Study Proposal

- Applying the CBRS brokering concept in to European Licensed Shared Access spectrum sharing
- Deployment of the spectrum trading and leasing framework in collaboration with the government, industry, and academia
- Utilization of blockchain technology to reduce transaction costs



# Conclusions

- CBRS secondary market, micro-operators, and events provide demand for secondary market place
- Auctions determine price when item has several buyers. Fixed automated pricing serves secondary licenses
- Peer-to-peer marketplace software can be modified for secondary spectrum market



