Designing a System for Reallocation of Spectrum

Implications from a Conceptual Study

Workshop on Spectrum Management in a Liberalized Environment:

Implications for Thailand and Lao PDR

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I. Introduction

A. Objective of this paper

design and analyze economic mechanism for spectrum trade

extended market mechanism (EMM)

B. Strategy for the work

two-step designing

(1) to design an "ideal" system from scratch

(2) to design transition process from current state to ideal system

C. Properties of the ideal system

(1) a process of stepwise reallocation

(2) each step Pareto-improves spectrum allocation (no user shall be hurt)

II. Spectrum as an economic resource---Overview

A. What is spectrum?

a space resource with limited capacity

no depletion, no depreciation

can be used in exclusive or shared mode

externalities, positive and negative

technological progress increases efficiency

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B. Division of spectrum into bands/blocks

band: a segment of one-dimensional frequency space (Fig. 1)

block: (of the terrestrial spectrum) (Fig. 2)

a subset of three-dimensional space composed by the frequency space and the surface of the land (Fig. 3)

C. Incumbent users of spectrum blocks

obtain returns from using block(s)

with externalities

investment made in the past

sunk cost

cost of holding block(s)

no physical cost

there may be institutional cost

ex.: spectrum usage fee

local monopoly

D. Potential users of spectrum blocks

may form a plan for using block(s)

usage plan

returns forecast

may offer demand price for block(s)

ex.: through auction

E. Pareto-improving reallocation of block(s) (1)

For block(s) being reallocated,

(returns from the current use)

< (returns from a potential use)

F. Pareto-improving reallocation of block(s) (2)

For both incumbent and new users,

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(returns before reallocation)

≦(returns after reallocation)

G. Ordinary market mechanism (MM) for reallocation

Offer by potential users:

may be done with combinations of blocks

considering (positive) externalities

Response by incumbent:

will use power of local monopoly

strategic use of (positive) externalities

may quote an extremely high price for yielding a block

MM will not function for spectrum reallocation

H. Reasons that MM does not function for spectrum reallocation

(1) conditions for MM to function efficiently:

a. perfect information
b. competition with both demand and supply
c. goods to be traded: homogeneous or with perfect substitutes
d. no externalities
e. individuals have incentive to trade

(2) with spectrum as an object of trade:

a. (perfect information) may be assumed
b. (competition) not satisfied; local monopoly with supply
c. (perfect substitutes) do not exist; spectrum block is unique areawise and frequencywise
d. (externalities) exist, positive and negative
e. (incentive of trading) weak with incumbents because of sunk cost and zero holding cost

III. Overview of EMM, proposed

A. Bill of spectrum rights and responsibilities (proposed)

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(1) Spectrum is a property owned by the society collectively.

(2) Spectrum may be used exclusively by a user for an **indefinite period**; the right to use spectrum, however, is by no means permanent.

(3) The user shall pay a usage fee to the government.

(4) The user shall yield spectrum right when requested with a compensation which exceeds the amount specified by the user himself/herself prior to such a request.

(5) Reallocation of spectrum shall be Pareto-improving.

B. Division of spectrum management (Fig. 4)

(1) government:

specification of bands, blocks

technological requirements

formation of *block structure (groups)* (→ III.C)

(2) EMM:

specifies block users

C. Block structure (Fig. 5)

tree-type (hierarchical) grouping of blocks

a spectrum ***group*** is either

a block, or

a collection of blocks, or

a collection of groups.

(may be defined mathematically as a *tree*, a subcategory of *graphs*, where end nodes (leaves) are spectrum blocks)

D. Allocation and reallocation of spectrum to users

to be determined by EMM

users: participate to EMM

incumbents and potential users

government: regulates EMM

does not determine spectrum users

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--- this is the objective of the paper

IV. Functioning of EMM, proposed (Fig. 6)

A. Objective

to realize possible Pareto-improving reallocation of spectrum blocks

the "speed" of improvement: to be controlled by the government

B. Rights and obligations of incumbents

(1) Revelation of supply price (*c*) of each group (block)

c: the least amount of compensation for which incumbent agrees to yield the right of using the group

(2) Payment of spectrum usage fee (*R*)

$R = r\,C.$

C: the sum of *c*'s declared with **top-level** groups

r: (annual) rate of spectrum usage fee to be determined by the government

(3) Incumbents

may continue using a group if there is no offer > *c*

must yield the block if there is an offer $\geqq c$

(4) Determination of *c* by incumbents:

Incumbents tend to declare

a high *c* for continuing the use of a group

a low *c* for saving payment *R*

tradeoff to incumbents

"holding up" a block or a group may be costly

(5) Who are "incumbents"?

all users of spectrum

private, business, and government users

C. Rights and responsibilities of potential users

(1) Obtain information of *c*'s and *C*'s

(2) Make offers by showing demand price (*D*) for groups (blocks) chosen

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(3) If there is no competing offer,

then potential user obtains spectrum right for paying *D*.

(4) If there is a competing offer,

then auction will be conducted on such groups

winning potential user obtains spectrum right for paying *D*.

D. Roles of government with EMM (1): spectrum holding fee

(1) determines a fee rate (*r*):

to control the speed of reallocation

resembles to determination of discount rate by central bank

(2) receives spectrum fees (*R*)

E. Roles of the government with EMM (2): market auctioneer

(1) conducts auction for each group with $D > c$

use combinatorial auction (computerized)

bidding rule, stopping rule

determines winning bids so as to maximize the total amount of bid price minus *c*

(= total surplus)

(2) receives total surplus

(Figs. 7A, 7B)

F. Roles of the government (3): collection and dissemination of information

(1) *c*, *C*, *D*, auction process, auction results

(2) the state of spectrum rights:

registration

information disclosure

G. Outcome from EMM:

Pareto-improving reallocations will be realized gradually step by step

speed of reallocation is controlled by *r*

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V. Secondary (indirect) users of spectrum with EMM

A. Commons users (Fig. 8):

primary user: a government administrator

secondary users: general users (the public)

C: the sum of all compensations declared by the users

R: may be collected at purchasing a device for using a commons block

(payment may be made together with that of insurance fees for breakage)

B. Subscribers to service using spectrum (Fig. 9):

ex.: mobile phone users

wireless internet users

primary user: providers, broadcasters

secondary users: subscribers, "users"

C: the sum of compensations declared by the primary and the secondary users

R: may be collected by primary user from secondary users to remit to government

C. Transition to DTV in the presence of EMM

would have been a case of reallocation of commons blocks under EMM

VI. Introduction of reallocation as a forward trading, forward supply price

EMM with timing of reallocation specified

ex.: reallocation *x* years after the current year

x = 1,3,5 and 10 years

c, *C*, *D*, *r* to be specified for each *x*.

EMM is applied for each *x*.

actual reallocation to be done in the year *x*.

both incumbent and potential users will be benefited.

VII. Preventing speculation with EMM (Figs. 10A, 10B)

speculation is possible on a strategically positioned block wrt externalities

regulation:

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impose a penalty on a steep increase in *C*

VIII. Transition from the current system to EMM

gradual transition is recommended

no “big bang”

set *r* at a level close to zero initially

increase *r* gradually thereafter

decrease the rate for current spectrum fees simultaneously

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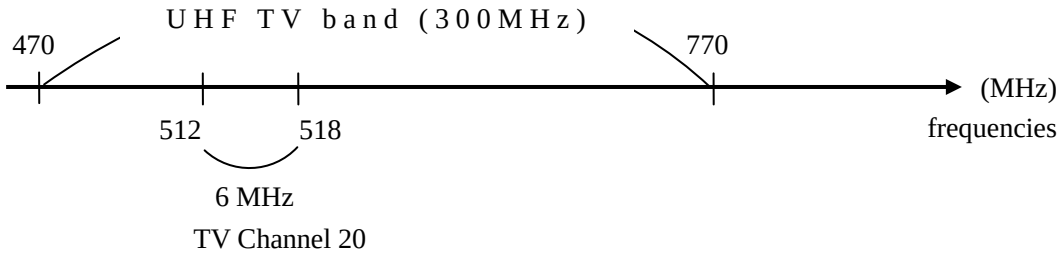

Figure 1: Examples of Spectrum Band in the Frequencies Axis

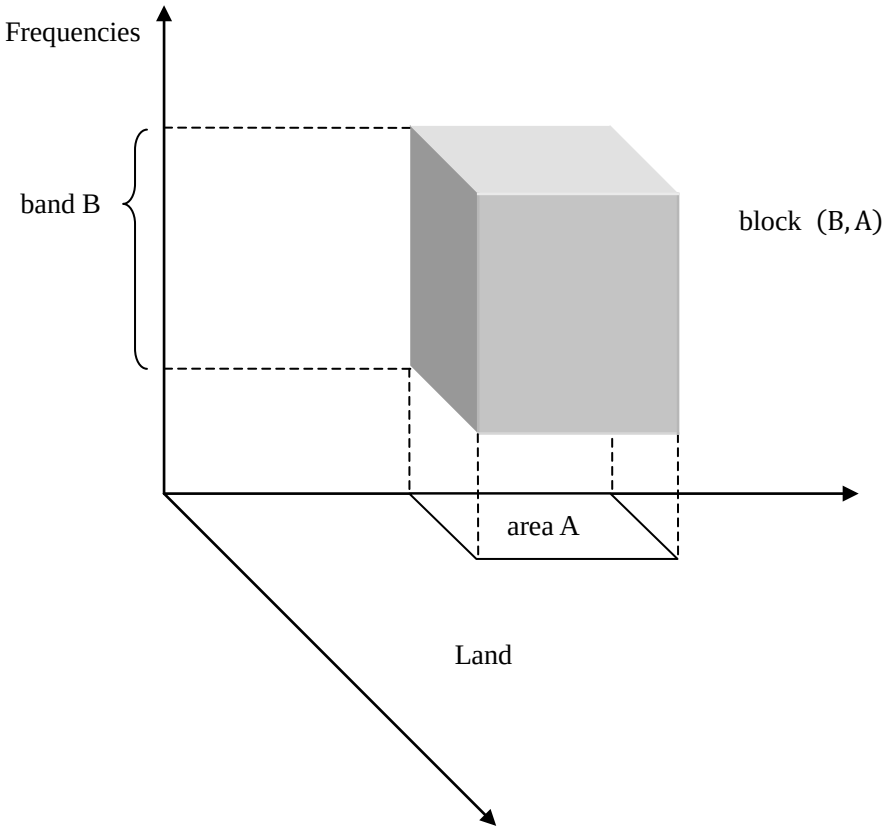

Figure 2: Example of Spectrum Block(B, A) in the 3-dimentional Spectrum Space

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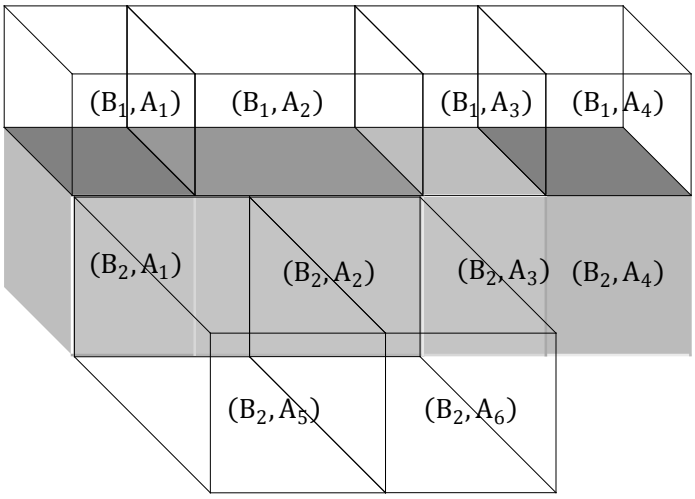

Figure 3A: Example of 10 Spectrum Blocks

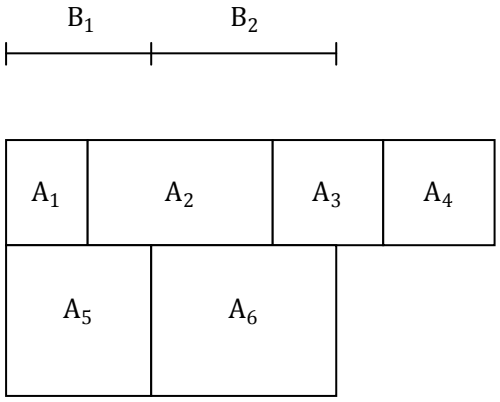

Figure 3B: 2 Bands and 6 Areas for the Blocks of Figure 3A

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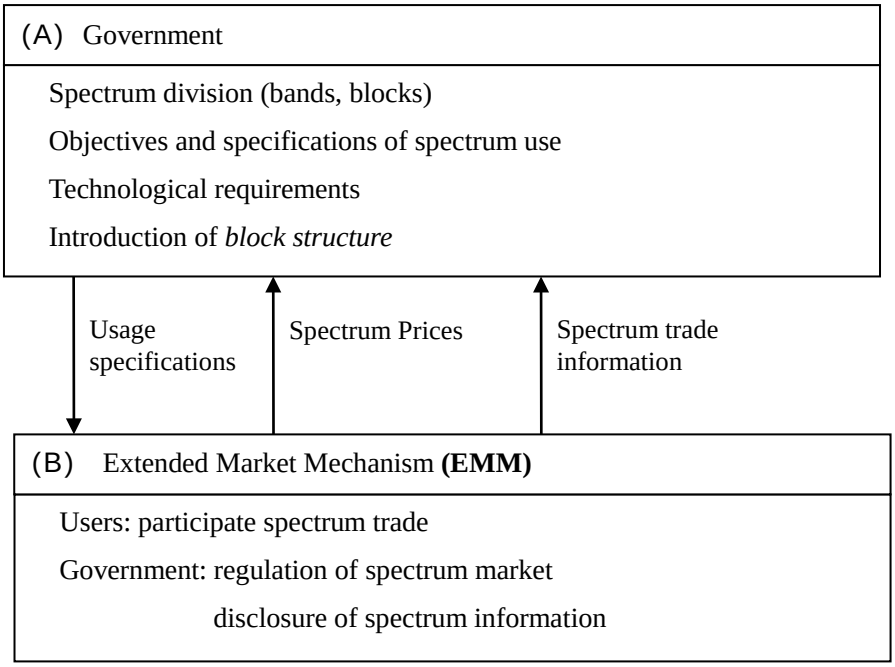

Figure 4: Overview of spectrum use with EMM

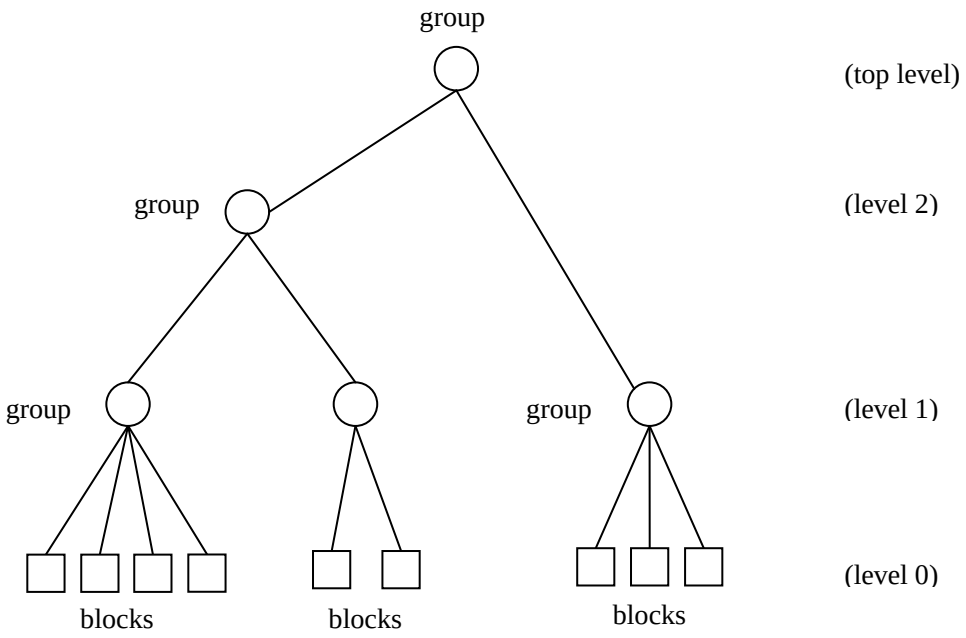

Figure 5: Spectrum Groups (Block Structure)

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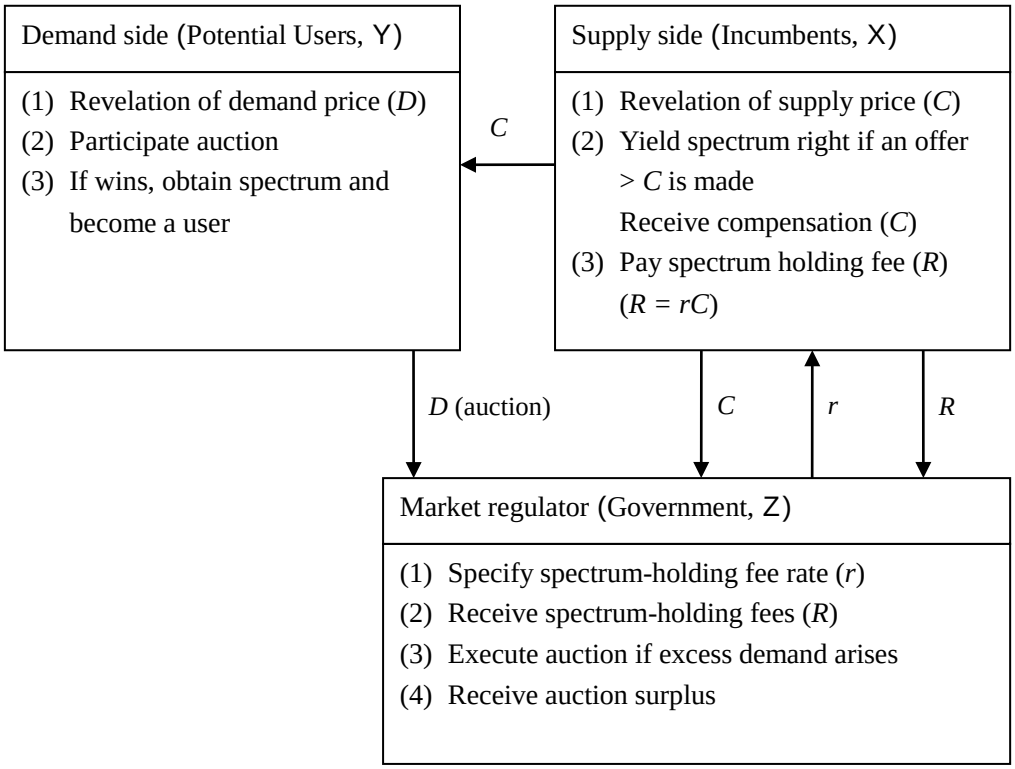

Figure 6: Organization of EMM

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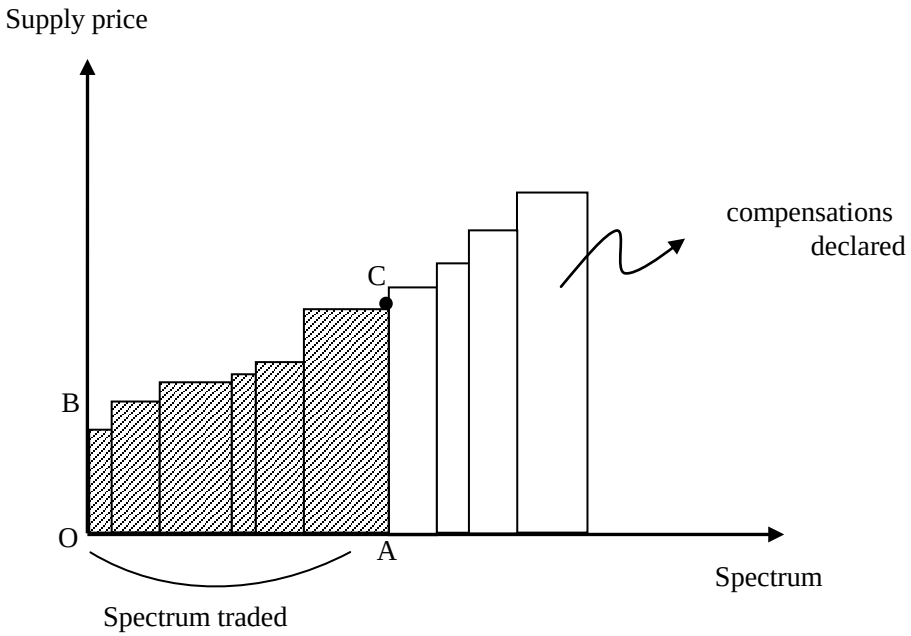

Figure 7A: "Supply" of Spectrum

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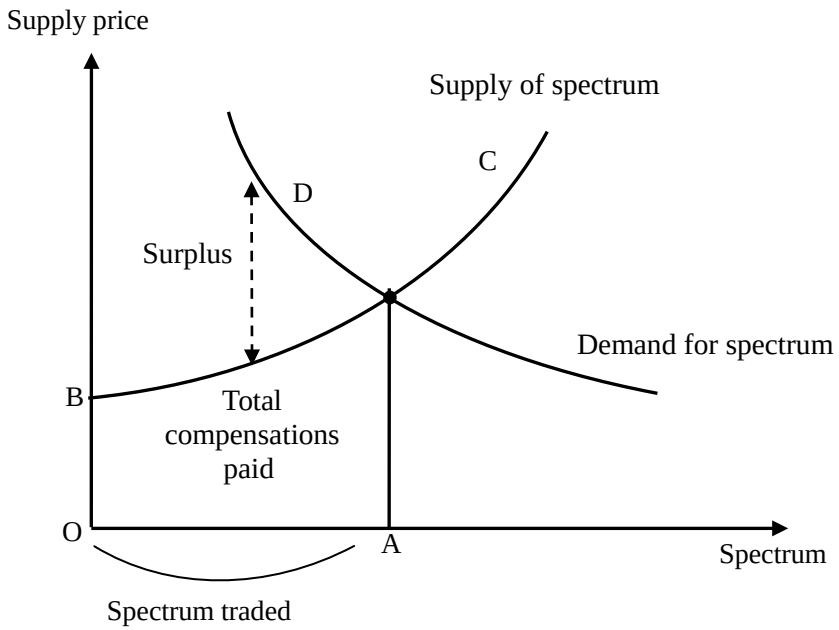

Figure 7B: "Demand and Supply" of Spectrum

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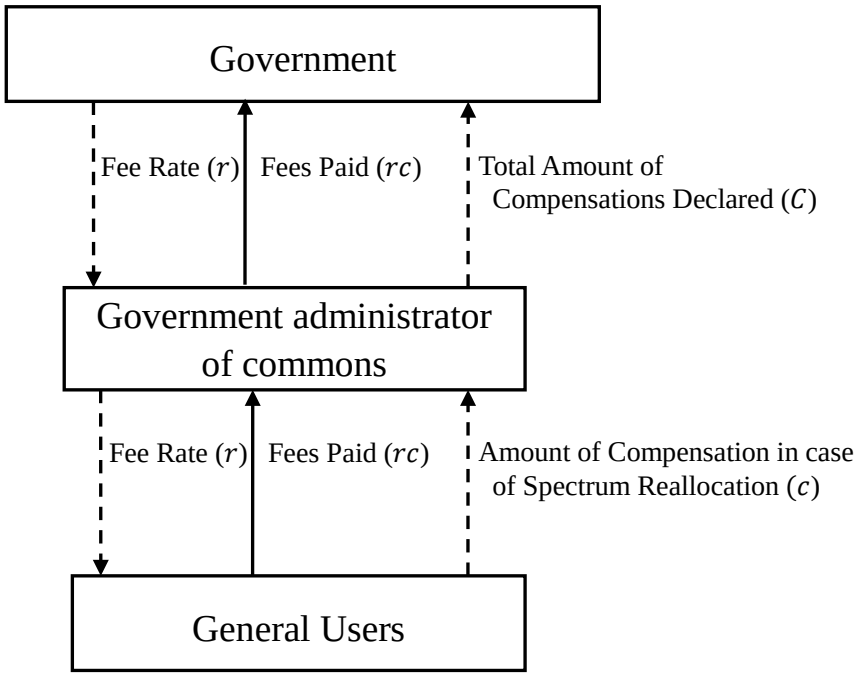

Figure 8: Supply Price Revealed by Commons Users

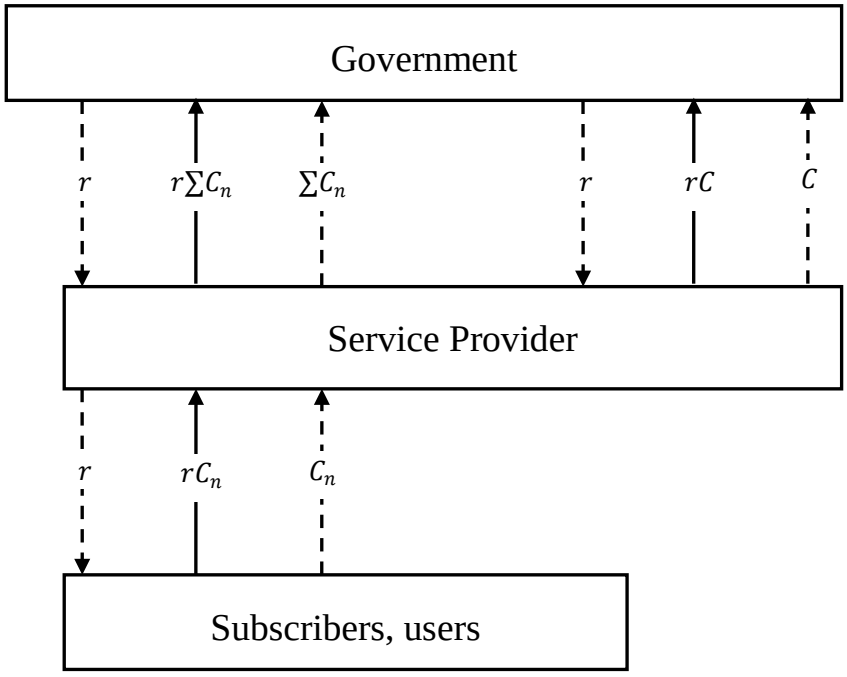

Figure 9: Supply Prices Revealed by a Service Provider and Subscribers

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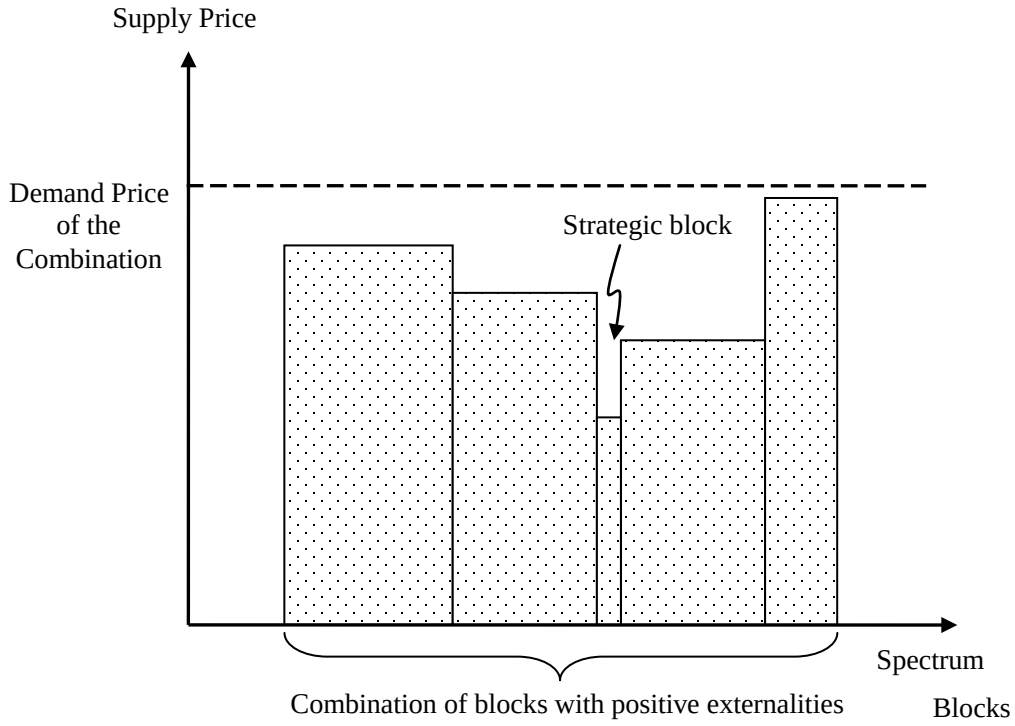

Figure 10A: Example of truthful supply prices

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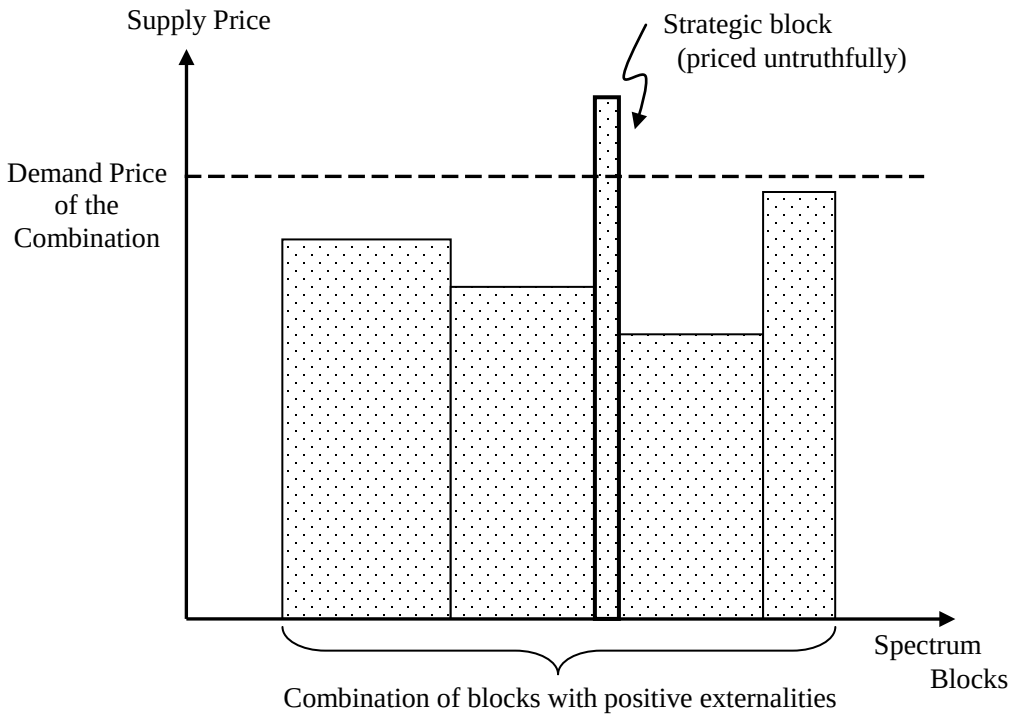

Figure 10B: Example of truthful and untruthful supply prices

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