



“Allocation and Assignment of Radio-Spectrum Resources by using Price Mechanism: Proposals for a New System”

WORKSHOP on Advanced Wireless Technologies:
Implications for Spectrum Management
European Commission, DG Information Society, IST Program
Brussels, 10/10/2003
Hajime ONIKI
Osaka-Gakuin University, Japan
oniki@alum.mit.edu
www.osaka-gu.ac.jp/php/oniki/

2

Contents:

- I. Introduction and Background**
- II. Present System of Spectrum Utilization**
- III. Provision for Spectrum Commons as a Public Good**
- IV. Re-allocation of Spectrum Bands with Compensation
-----An Insurance-Compensation System with Proper Incentives**
- V. Re-assignment of Spectrum Blocks ----- Modified Lease Auction (MLA)**
- VI. Gradual Transition to MLA**
- VII. Conclusion**

I. Introduction and Background

A. History of spectrum use: technological progress

B. Administration of spectrum resources

C. Emergence of spectrum shortage



H. Oniki

10/10/2003

A. History of spectrum use: technological progress

**1. Early 20-th century
used for maritime navigation
navy operations**

**2. 1920's
voice-radio broadcasting**

**3. 1930-40's
military use, radars**



H. Oniki

10/10/2003

A. History of spectrum use: technological progress

4. 1950's
television broadcasting, FM radio

5. 1960's ~ present
many applications including mobile
telephony,
wireless Internet, etc.



C. Emergence of spectrum shortage

1. End of spectrum-frontier expansion
no more spectrum band of “good quality”
upper limit: 3-5 GHz

2. Emergence of new technologies
possibility of “spectrum commons”
spread spectrum, underlay, UWB,
software radio



C. Emergence of spectrum shortage

4. Emergence of new technologies

b. observation:

significant increase in spectrum capacity

new technologies are created for using “unlicensed bands”

proposals of open use to replace licensing (“commons” campaign)



II. Present System of Spectrum Utilization

A. Spectrum as an economic resource

B. Allocation of spectrum bands (ALLOC)

C. Assignment of spectrum blocks (ASSGN)

D. The challenge in the age of spectrum shortage



A. Spectrum as an economic resource

1. One of *space resources*

a. physical spaces:

**land, water surface, aviation space,
satellite orbits, etc.**

b. electromagnetic spaces:

radio spectrum, optical spectrum.



A. Spectrum as an economic resource

5. Modes of utilization

a. Exclusive use

b. Club use

c. Commons use



B. Allocation of spectrum bands (ALLOC)

1. Outline

- a. *zoning* of spectrum**
- b. two-level system:
country and international**
- c. no price mechanism is used
command and control
direct negotiations**



C. Assignment of spectrum blocks (ASSGN)

3. Exclusive use----alternative systems for ASSGN

- a. Traditional system**
 - assignment by country government**
 - comparative hearings (beauty contest)**
 - lotteries**
 - zero or nominal rent**
 - automatic (or likely) renewal of
license at expiration**



C. Assignment of spectrum blocks (ASSGN)

3. Exclusive use----alternative systems for ASSGN

b. Private-property (or semi-private property) system

assignment with auction

competitive price paid in one installment

automatic (or likely) renewal



H. Oniki

10/10/2003

C. Assignment of spectrum blocks (ASSGN)

3. Exclusive use----alternative systems for ASSGN

c. Competitive lease system *(V.)

assignment by country government with

auction on lease price

competitive lease price paid

re-assignment with auction at expiration

no automatic renewal

modifications in favor of incumbents



H. Oniki

10/10/2003

C. Assignment of spectrum blocks (ASSGN)

4. Club use

a. Traditional system

licensing by country government

unlimited entry

zero or nominal rent

automatic renewal

examples: amateur wireless, navigation, aviation

b. *privatized* club use *(III.)



H. Oniki

10/10/2003

C. Assignment of spectrum blocks (ASSGN)

5. Commons-----open use

a. traditional system

no licensing

power limit

b. commons as a public good *(III.)



H. Oniki

10/10/2003

D. The challenge in the age of spectrum shortage

1. Present state

incumbent users with vested interests

free and continuing use

2. Need for *re-allocation*

emergence of new objectives for spectrum use



H. Oniki

10/10/2003

D. The challenge in the age of spectrum shortage

3. Need for *re-assignment*

new users, new business

4. Need for accommodating new technologies

for spectrum sharing

5. *The challenge:*

gradual but steady improvement



H. Oniki

10/10/2003

III. Provision for Spectrum Commons as a Public Good (A Proposal)

A. Outline

B. Proposals *



H. Oniki

10/10/2003

A. Outline

1. Technology for spectrum sharing

- a. to increase efficiency and flexibility by sharing a spectrum block with many users**
- b. new technology
SS, CDMA, underlay, UWB**



H. Oniki

10/10/2003

A. Outline

1. Technology for spectrum sharing
 - c. *old technology*
amateur wireless, navigation use,
aviation use
 - d. commons for using land space
public parks, street roads, town
commons



A. Outline

2. Outcome from using commons:
 - a. depends on demand (number of users) and
supply (capacity of spectrum block)
 - b. efficient use with *ample capacity*
 - c. congestion with *capacity shortage*
 - d. outcome may change in the long run
from free use to congestion



A. Outline

3. Observation

- a. **spectrum sharing under direct governmental control (Mode-G)**
commons: ISM
clubs: navigation and aviation, outdoor wireless-LAN



H. Oniki

10/10/2003

A. Outline

3. Observation

- b. **Spectrum sharing under private licensee's control (Mode-L)**
commons:
free broadcast to viewers
clubs: mobile telephony, pay-per-view broadcast



H. Oniki

10/10/2003

A. Outline

3. Observation

- c. mode-G commons may lead to
congestion and inefficient use,
but re-allocation is difficult
need for creating an *agent* representing
mode-G commons interests
to avoid formation of unlimited rights of
using spectrum



B. Proposals*

1. Preference of Mode-L to Mode-G for spectrum sharing

- a. strong incentives for efficient use
- b. convenience for re-allocation and
re-assignment



B. Proposals*

2. Mode-G spectrum sharing (spectrum as a *public good*)

- a. establish a *public agent* to administer Mode-G spectrum clubs or commons
to avoid formation of unlimited rights of using spectrum



H. Oniki

10/10/2003

IV. Re-allocation of Spectrum Bands with Compensation -----An Insurance-Compensation System with Proper Incentives

- A. Outline
- B. Insurance-compensation system for re-allocation within a country* (a proposal)
- C. International insurance-compensation system for spectrum re-allocation* (a proposal)



H. Oniki

10/10/2003

A. Outline

1. **Re-allocation of spectrum bands**
 - a. **need arises from technological progress and changes in demand**
 - b. **shortage of spectrum bands to meet new demand**
 - c. **shortage is a global (frequency-wise) problem over all spectrum bands**



A. Outline

1. **Re-allocation of spectrum bands**
 - d. **re-allocation is to be made locally with a single band**
 - e. **a band to be re-allocated is a “sacrifice” for the benefit of other users**
 - f. **need for compensation to outgoing users at re-allocation, the cost should be paid by all users**



B. Insurance-compensation system for re-allocation within a country (a proposal)

1. Acceptable compensation and premium

- a. acceptable compensation to be declared by each spectrum user**



H. Oniki

10/10/2003

B. Insurance-compensation system for re-allocation within a country (a proposal)

1. Acceptable compensation and premium

- b. annual compensation premium to be paid by each spectrum user annually to spectrum manager (country government)
= (declared acceptable compensation) times (premium rate)**



H. Oniki

10/10/2003

B. Insurance-compensation system for re-allocation within a country (a proposal)

2. Premium rate and government budget

a. premium rate

to be determined by spectrum manager so that the total annual income from the compensation premiums be equal to the total annual compensations paid for the re-allocation in the year.



B. Insurance-compensation system for re-allocation within a country (a proposal)

3. Determination of spectrum bands to be re-allocated

- a. indicator of efficiency increase from re-allocating a band: = $(B - C) / A$, where**
- A = (present value of using the band under old objective)**
- B = (present value of using the band under new objective)**
- C = (amount of compensation for the re-allocation)**



B. Insurance-compensation system for re-allocation within a country (a proposal)

- 3. Determination of spectrum bands to be re-allocated**
 - b. maximum efficiency indicator**
the band with the highest efficiency indicator (which exceeds 1) is to be chosen for re-allocation
an incentive for honest declaration of acceptable compensation by users



C. International insurance-compensation system for spectrum re-allocation (a proposal)

- 1. Group of country governments for international insurance-compensation system (GIIC)**
 - a. to be formed voluntarily by country governments**
 - b. objectives:**
to administer international insurance-compensation for re-allocation to reveal information of the supply price of spectrum bands via compensation



C. International insurance-compensation system for spectrum re-allocation (a proposal)

- 2. Acceptable compensation and premium**
 - a. to be declared by each member country for each band**
 - b. annual compensation premium to be paid by each member country annually to GIIC**
= (declared acceptable compensation) times (premium rate).



C. International insurance-compensation system for spectrum re-allocation (a proposal)

- 3. Premium rate and determination/recommendation of spectrum bands to be re-allocated internationally**
 - a. premium rate to be determined by GIIC so as to balance its annual budget**
 - b. indicator of efficiency increase from re-allocating a band internationally (same as in V.B.3.a)**



C. International insurance-compensation system for spectrum re-allocation (a proposal)

3. Premium rate and determination/recommendation of spectrum bands to be re-allocated internationally

d. GIIC

**executes or recommends (to ITU, EC) the choice of the band (in c. above)
pays compensation to each member country according to re-allocation agreement made in ITU, EU.**



H. Oniki

10/10/2003

C. International insurance-compensation system for spectrum re-allocation (a proposal)

4. Behavior of a member country of GIIC

a. member country with a domestic insurance-compensation system operates with two *accounts*:



H. Oniki

10/10/2003

C. International insurance-compensation system for spectrum re-allocation (a proposal)

4. Behavior of a member country of GIIC

with GIIC system:

**represents GIIC to domestic users as a
(neutral) intermediary**

**domestic users deal in effect directly with
GIIC**

**decreases incentive for dishonest declaration
of acceptable compensation by users**



C. International insurance-compensation system for spectrum re-allocation (a proposal)

4. Behavior of a member country of GIIC

**with domestic insurance-compensation system
for domestic re-allocations:**

**users pay annual premium both to GIIC
and domestic government**

domestic budget will be balanced



C. International insurance-compensation system for spectrum re-allocation (a proposal)

4. Behavior of a member country of GIIC

- b. member country without a domestic insurance-compensation system
needs to estimate acceptable compensation
for each band
budget from paying premiums and
receiving compensations need not balance**

