Pricing Wireless Service with MVNO Participation

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Introduction

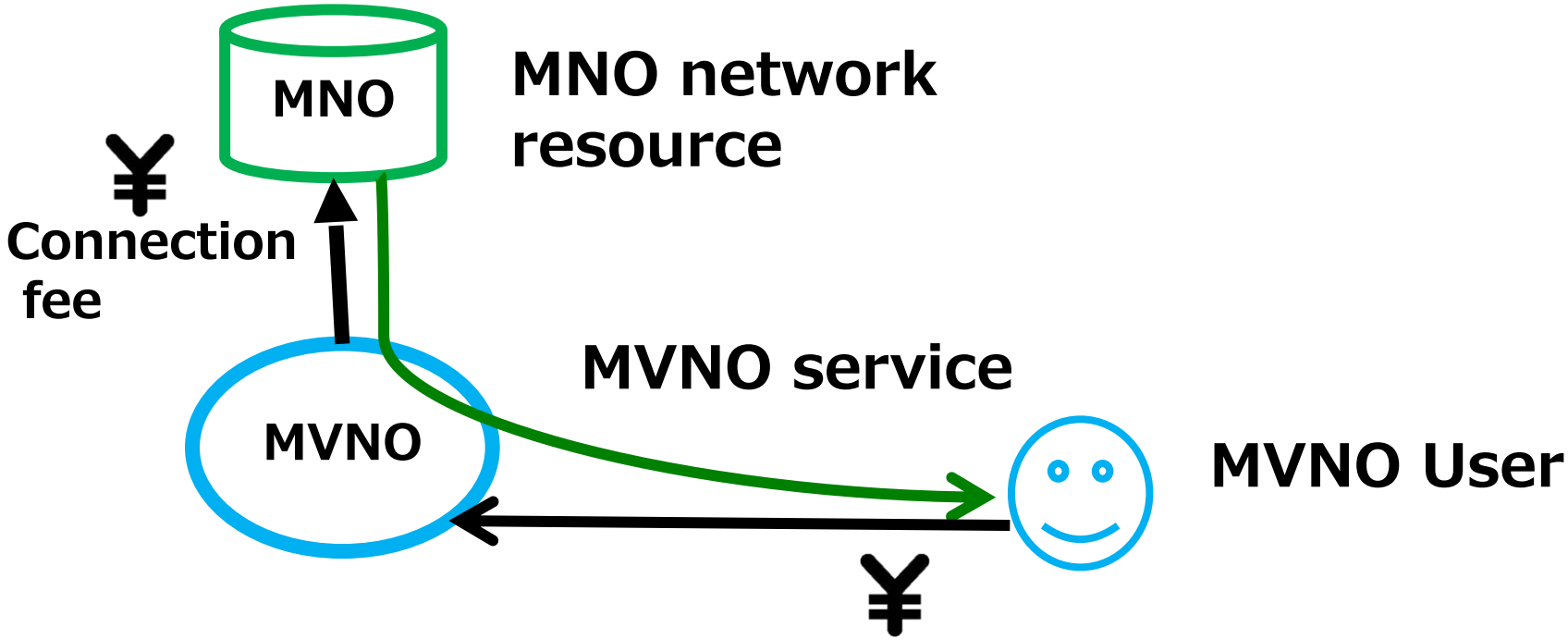
- Mobile market is often in an oligopoly state of MNO
  - There is no flexibility, side-by-side services of each company
  - New market entry is difficult
    - Radio spectrum are finite and scarce
    - Huge capital investment required
  - MVNO is expected to stimulate competition

Table 1 Data plans of three major MNOs in Japan.

Company		NTT docomo	KDDI	SoftBank
Data plan	2GB	3500 yen	3500 yen	3500 yen
	5GB	5000 yen	5000 yen	5000 yen
	20GB	6000 yen	6000 yen	6000 yen

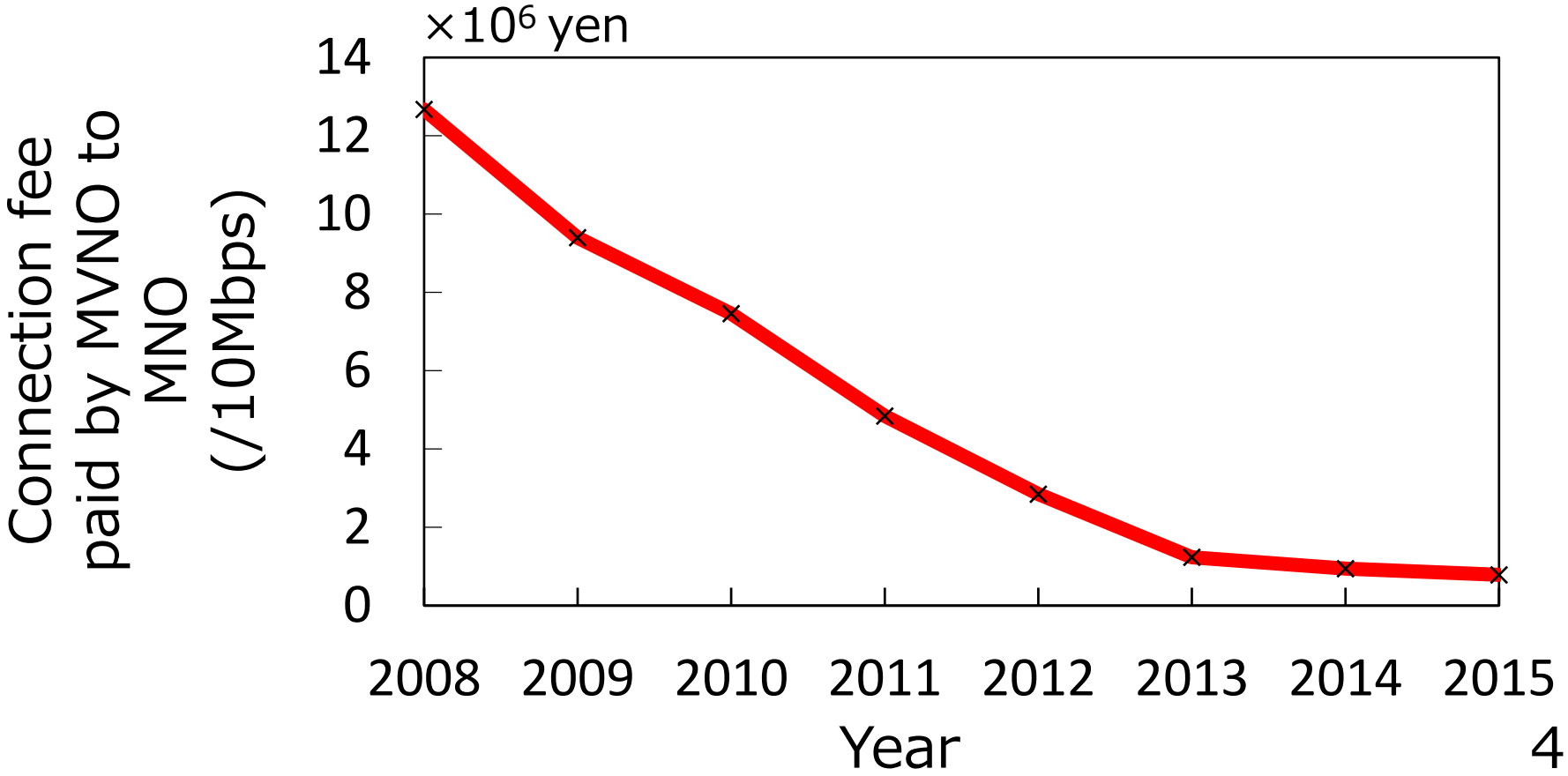
MVNO (Mobile Virtual Network Operator)

- MVNO does not hold spectrum licenses
- MVNO pays a connection fee to Mobile Network Operator (MNO) and provides service by using MNO network resources



Connection fee shifting trend in Japan

- Connection fee shifting trend in Japan
  - Connection fee became cheap year by year
  - MVNO became possible to provide inexpensive service



Comparison between MNO and MVNO

- MNO and MVNO share MNO's network resources
  - The proportion of network resources used by MNO and MVNO respectively affects the communication quality

Table 2 MVNO and MNO price.

Operator Type	Data plan price/manth	Mean transmission rate [Mbps]	
	5G	peak	off peak
MNO	5000 yen	30.7	33.9
MVNO	2150 yen	1.5	17.9

  - MVNO is cheaper than MNO
  - This price difference is mainly due to the difference in transmission rate

Comparison between MNO and MVNO

- Large difference in transmission rate between MNO and MVNO

Table 3 Transmission rate around the Tokyo station.

Operator Type	Company	Mean DL speed[Mbps]	
		12:00 – 13:00	14:00- 15:00
MNO	NTT docomo	18.5	21.8
	KDDI	38.2	46.6
	SoftBank	35.4	33
MVNO	NTT com	0.9	15.7
	IIJ	2.3	19.7
	Rakuten	1.3	18.4

- These services are not optimal for intermediate users

Optimal price for maximize revenue

- View point this presentation
  - Current service for intermediate users is not optimal
  - MNO can not make effective use of network resources
    - As MVNO puts many users in a small amount of resources, as the share of MVNO increases, the resources of MNO become surplus
  - Decrease in revenue of MNO
    - If many MNO users switch to MVNO, MNO's revenue will decrease greatly
- Purpose
  - The optimal price for maximize operator's revenue

Service Model

- MNO sells the network resource to the MVNO
- MVNO provides middle class service
- MNO users don't switch to the MVNO

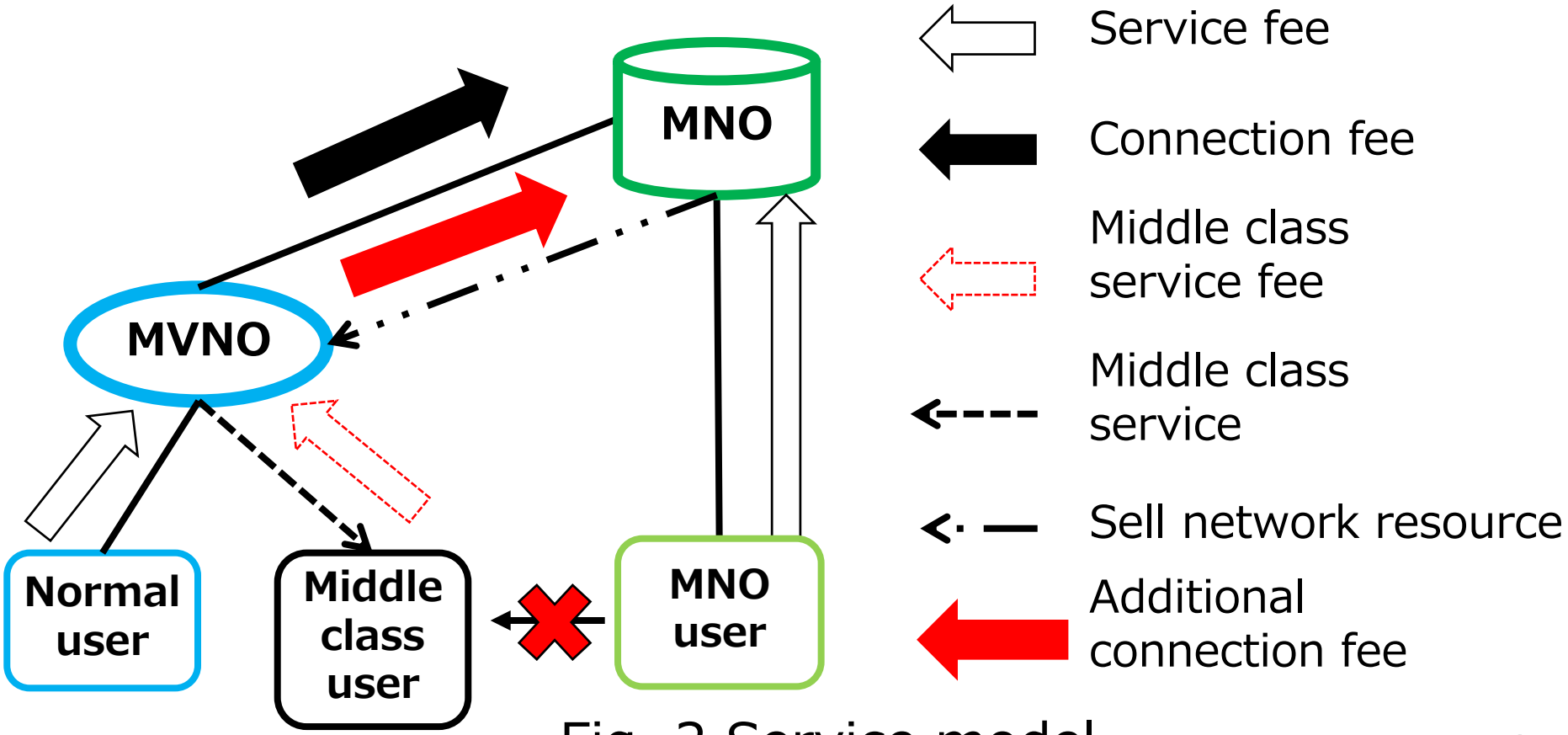


Fig. 2 Service model.

MVNO User's Behaviour Model

- Binary Logit Model
  - Assuming that the user compares all the options and chooses the option with the greatest gain
  - MVNO User's gain

$$U_1 = W(s_1) - c_1 \quad (1)$$

$$U_2 = W(s_2) - c_2 \quad (2)$$

U_1, user's gain of normal service

U_2, user's gain of middle class service

$W(s)$, user's utility function

s_1, transmission rate of normal service

s_2, transmission rate of middle class service

c_1, price of normal service c_2, price of middle class service

MVNO User's Behaviour Model

- User's utility depends on the willingness to pay(WTP)

$$W(s) = \alpha \times s^{\beta} \qquad (3)$$

β<1, increasing convex upward function

- User selection probability based on Binary Logit Model

$$P_1 = \exp(U_1)/(\exp(U_1) + \exp(U_2)) \qquad (4)$$

$$P_2 = \exp(U_2)/(\exp(U_1) + \exp(U_2)) \qquad (5)$$

P_1, probability that MVNO user selects normal service
P_2, probability that MVNO user selects middle class service

MNO and MVNO Revenue Model

- We only consider a monthly flat-rate pricing scheme
- MVNO's Expected Revenue

$$E(R_1) = n_1 \times P_1 \times c_1 + n_1 \times P_2 \times c_2 \quad (6)$$

n_1, number of MVNO's users

- MNO's Expected Revenue

$$E(R_2) = n_2 \times c_3 + b \times E(R_1) \quad (7)$$

n_2, number of MNO's users c_3, normal service fee of MNO
b, proportion of connection fee to MNO in MVNO revenue

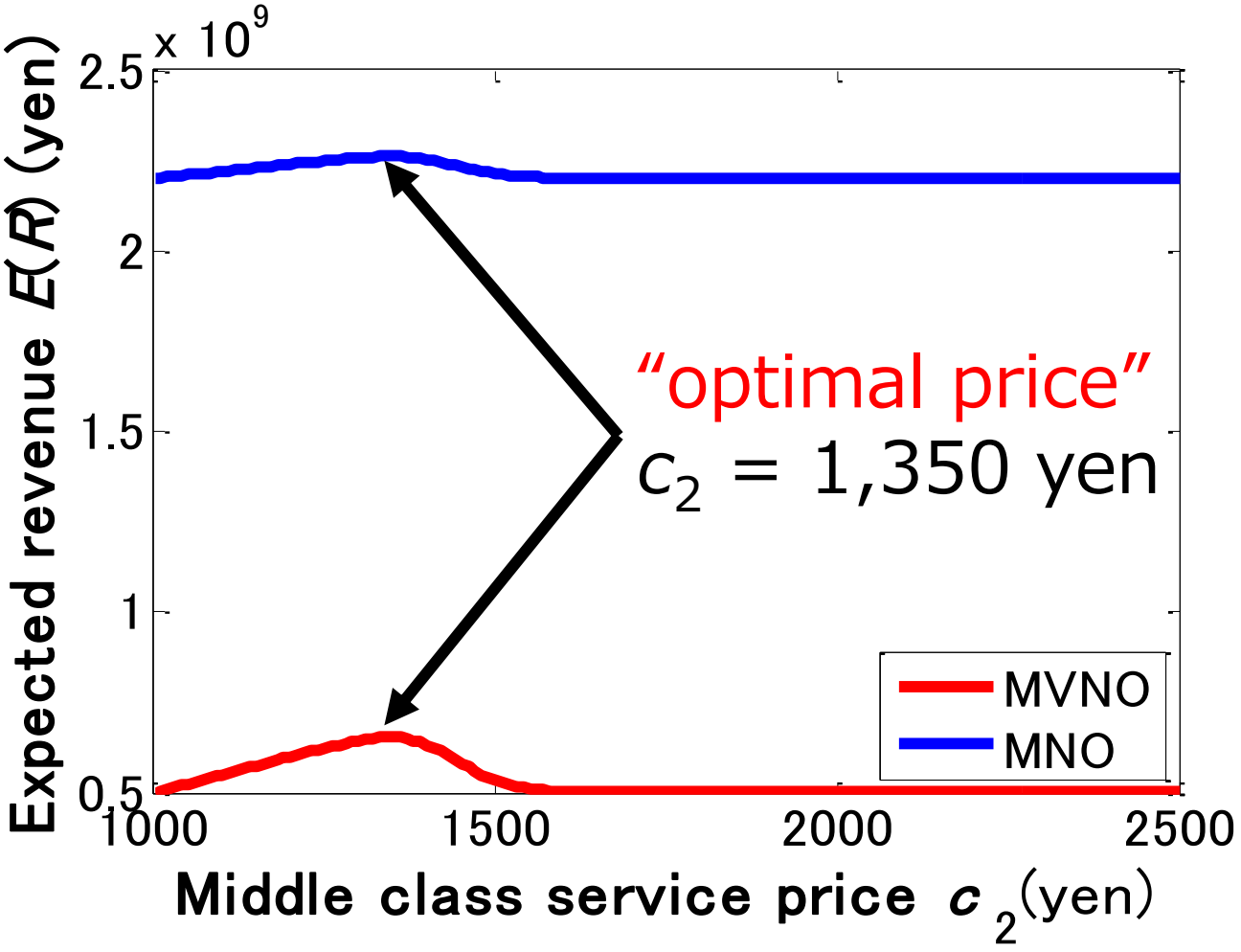
- When MVNO's expected revenue maximize, MNO's expected revenue will maximize too
- We need to choose optimal middle class service price c_2 to maximize MVNO's expected revenue as shown in Eq.(6)

Parameters setting

Table 4 Parameters setting.

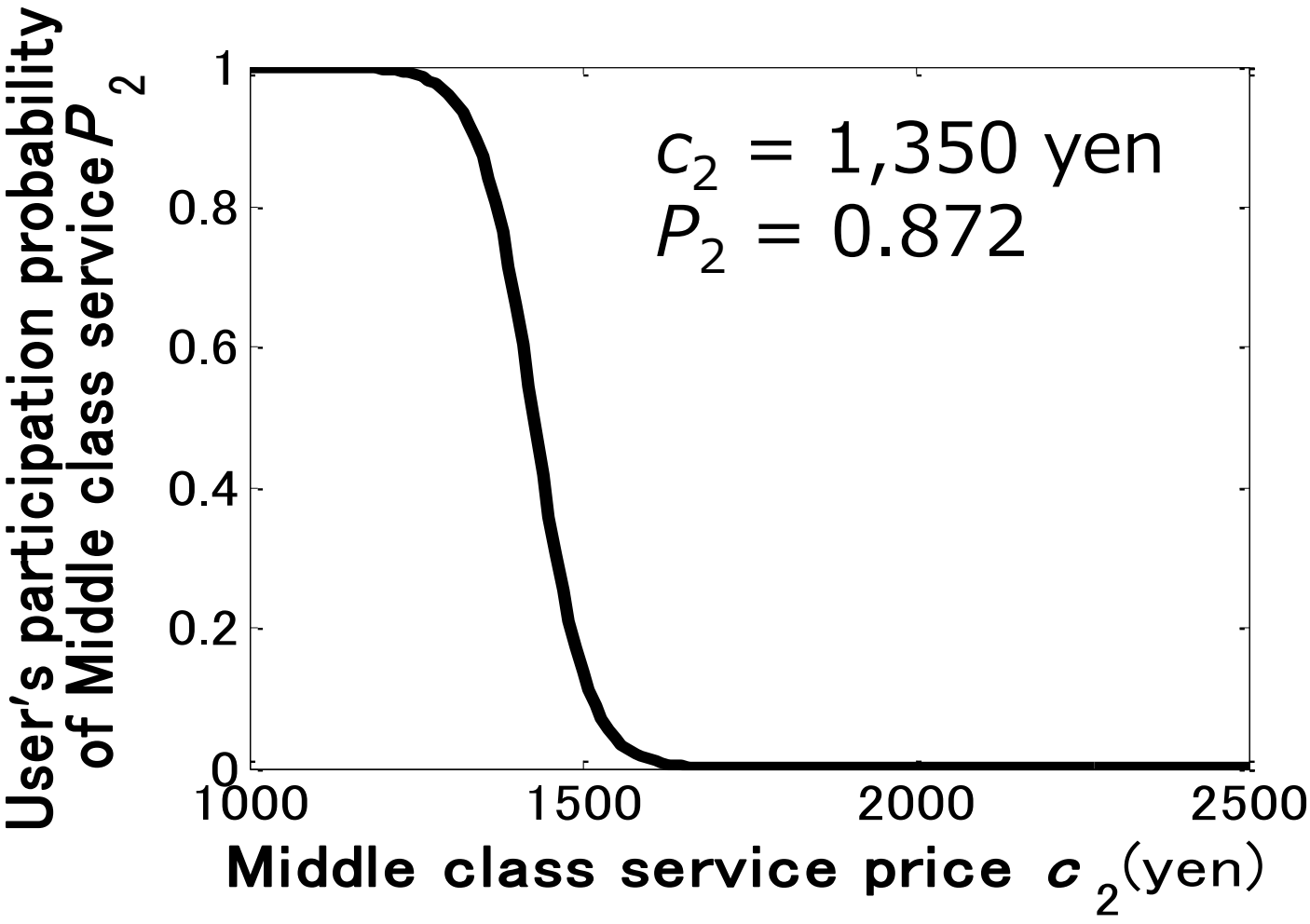
Descriptions	Parameters	Values
WTP parameter	α	1500
WTP parameter	β	0.3
Number of MVNO's users	n_1	0.5 million people
Number of MNO's users	n_2	0.5 million people
Mean transmission rate of MVNO normal service	s_1	2 Mbps
Mean transmission rate of MVNO middle class service	s_2	[4, 6] Mbps
MVNO's normal service fee	c_1	1000 yen
MNO's normal service fee	c_3	4000 yen
Ratio of connection fee in revenue of MVNO	b	0.4

Relation between price and expected revenue



QoS of middle class service s_2 =4Mbps

User's participation probability of middle class service



QoS of middle class service s_2 =4Mbps

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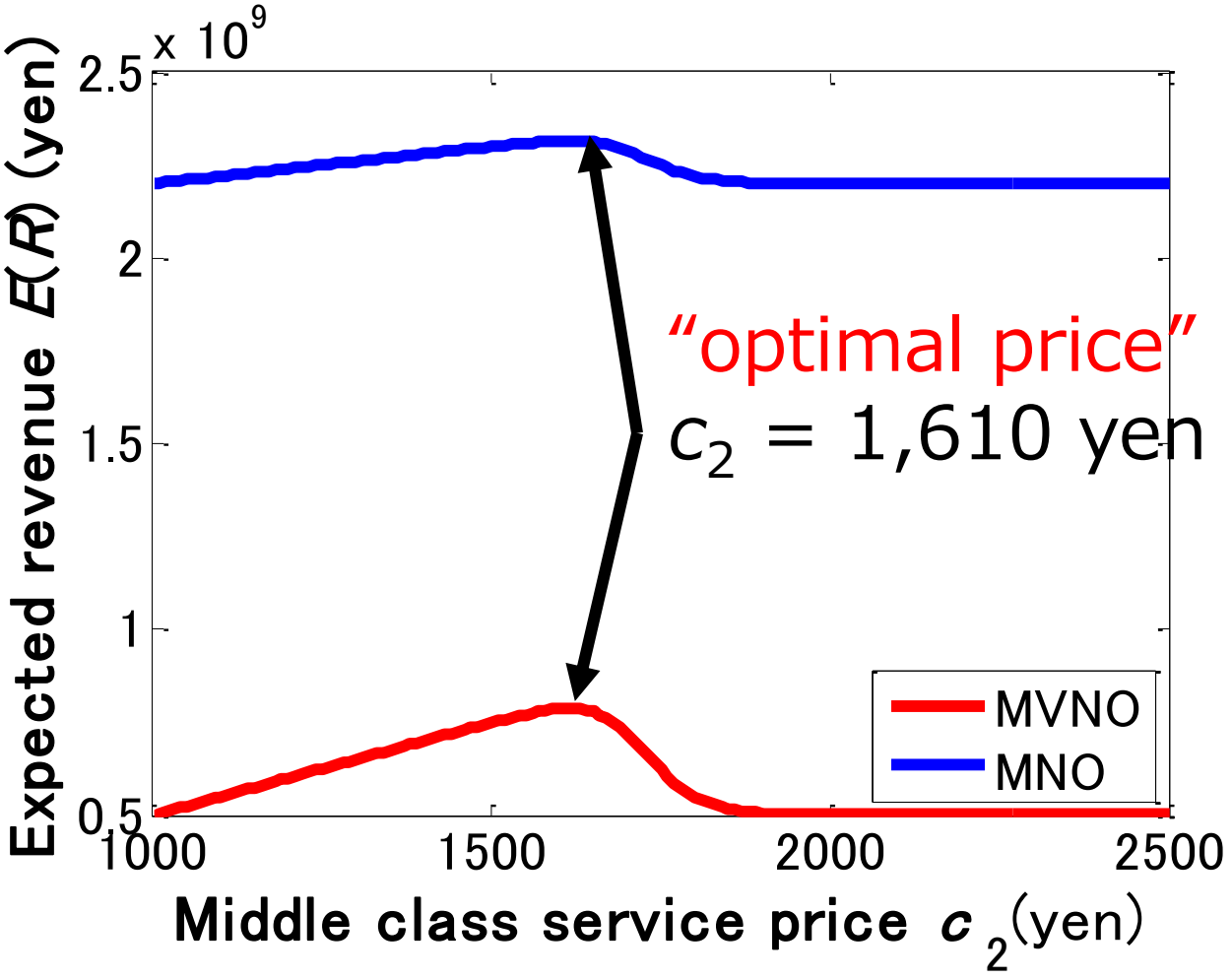
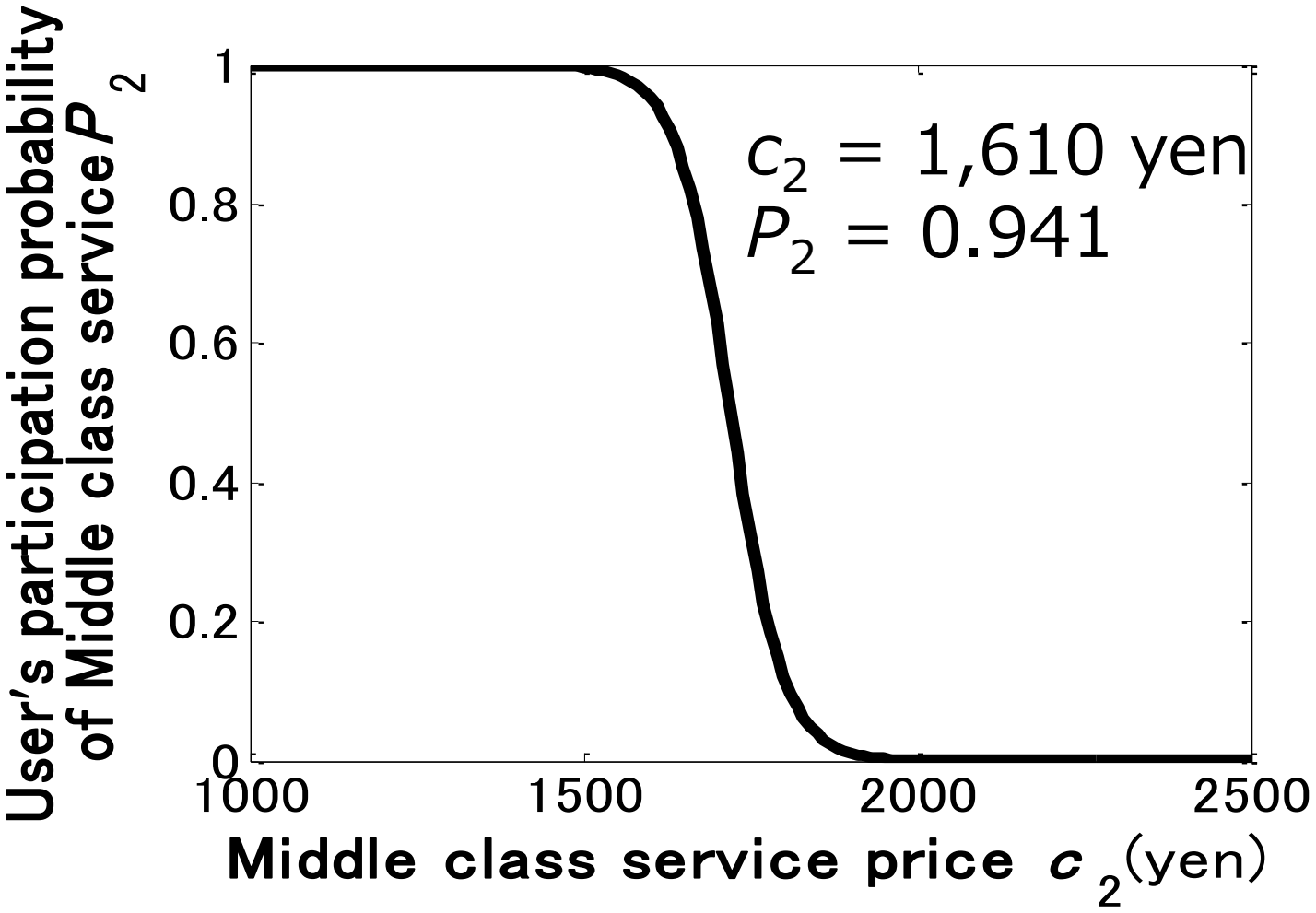


QoS of middle class service s_2 =6Mbps

User's participation probability of middle class service



QoS of middle class service s_2 =6Mbps

Conclusion

- Result
  - We showed the optimal price for maximize operator's revenue
  - Pricing based on network resource is also possible
  - The optimal price can be similarly obtained by changing the parameters setting

- Future Work
  - Consider MNO users' behavior
  - Set up willingness to pay function for best-effort service by questionnaire survey
  - Evaluate with a more realistic model by simulation

Thank you for your kind attention

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$W(s)$ function in this paper