Pricing Wireless Service with MVNO Participation

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Abstract

In recent years, Mobile Virtual Network Operators (MVNOs), which provide services by reselling network resources from Mobile Network Operators (MNOs), have grown rapidly. MVNOs provide agile pricing plans for light users, and the unfairness of charges on light users is therefore reduced. If this trend continues in the future, users who prefer low price will change to subscribe to MVNOs which offer relatively lower prices compared with MNOs. As a result, although MNOs charge MVNOs for using their resources, the revenue of MNOs may decrease as users switch from MNOs to MVNOs. As the market share of MVNO increases, the utilization of MNOs' network resources decreases. In this paper, we assume that MVNOs introduce a middle class service to their subscribers in order to efficiently utilize MNO's network resources. Furthermore, we clarify the optimal price of middle class service for maximizing revenue of MNO and MVNO.

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

1. Introduction

In recent years, MVNOs, which provide mobile communication service by reselling network resources from MNOs, have huge market share growth. Table 1 shows data plans of three major MNOs in Japan [1][2][3]. From Table 1, there is no flexibility, side-by-side services of each company. The conventional MNO data plan was a monthly flat-rate plan with an upper limit of data volume (e.g. 5 to 7 GB in Japan) that can be used in a month. Although it is a reasonable data plan for users who use 5 to 7 GB, it is expensive for users who only have little data demand per month. On the other hand, many MVNOs provide services for users with data volume of about 1 to 2 GB per month, and offer a lower price than that of MNOs. The number of choices increases for users, but as the number of users moving from MNO to MVNO increases, the number of MNO users decreases and MNO's revenue also decreases. As the market share of MVNO increases, there is a margin for MNO's network resources, but if there are too many users switching from MNO to MVNO, MNO's network resource, which can not generate revenue for MNO, may increase. There is also a considerable difference in the transmission rate between MNO and MVNO, and it is expected that there are MVNO users who are unsatisfied with the transmission rate.

Therefore, in this paper, we propose a model that MVNO provides middle class service by effectively utilizing MNO's network resources. The quality of service (QoS) of middle class service is assumed as that between MNO and MVNO. We derive the participation probability of middle class service firstly, then we clarify the optimal price for maximizing revenue of MNO and MVNO when middle class service is introduced.

Introduction

- 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
  - The connection fee became cheap year by year, and it became possible to provide inexpensive service

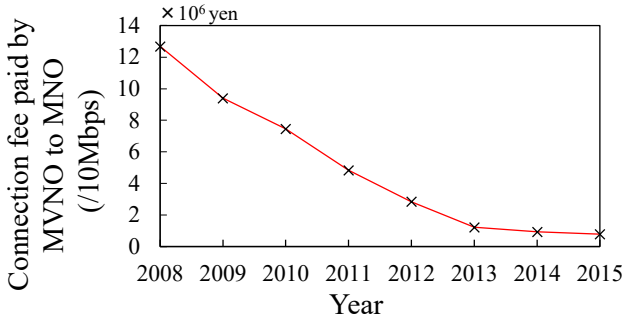


Fig. 1 Connection fee shifting trend in Japan.

2. MVNO

2.1 MVNO

MVNO is a kind of provider of mobile communication services without holding radio spectrum license and network infrastructure. Figure 1 shows connection fee shifting trned in Japan. MVNO provides mobile communication services by reselling network resources from MNOs. Currently, it is said that mobile market is in a cooperative oligopoly state of several MNOs [4]. Competition is indispensable for further activation of mobile communication services. Therefore, it is expected that new business operators will enter new entrants as MNOs, and offer competing services by providing different services from existing MNOs. However, radio waves are finite and rare, so efficient allocation is required and can not be allocated to many business operators [4]. In addition, it is not easy for new entrants to enter the MNOs market in the early stage, as enormous capital investment is required for new entrants. From these facts, the development of MVNO, which can provide services similar to MNO from the customer's point of view, is important in the mobile market.

Comparison between MNO and MVNO

Table 2 MVNO and MNO price.

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

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

2.2 Relation between MNO and MVNO

MNO and MVNO share the network resources owned by MNO because MVNO resells network resources of MNO to provide service. The amount of network resources is limited, and the proportion of network resources used by MNO and MVNO respectively affects the communication quality. In addition, an increase in MVNO users leads to an increase in revenue of MNOs because MVNO pays MNO a basic usage fee that is proportional to the number of its users and a flat-rate connection fee that depends on the size of the band to be used. On the other hand, MNO and MVNO are competing for users, because the number of users is limited. If many users of MNO switch to MVNO, there is a possibility that MNO's revenue will decrease greatly. That is, although MVNO is a customer for MNO, it is also a competitor that may deprive MNO of users. Table 2 shows the MNO and MVNO price [1][5]. From Table 2, MVNO is cheaper than MNO. This price difference is mainly due to the difference in communication quality. Table 3 shows the transmission rates of MNO and MVNO around the Tokyo station [6]. From Table 3, it can be seen that there is a large difference in communication quality between the peak time and the off peak time. At the peak time, the transmission rate of many MVNOs is 1 to 2 Mbps. Although the communication quality is sufficient for a user who uses a service requiring low data traffic, users who have high data traffic requirement can not easily be satisfied. For this reason, while users with low data traffic contract with MVNO can reduce their expense, Users with high data traffic contracts with MNO can enjoy high transmission rate. However, for intermediate users, the QoS of MVNO is unsatisfactory, and the QoS of MNO is excessive and the price of MNO is too high, so it can be said that the service for intermediate users is not optimal.

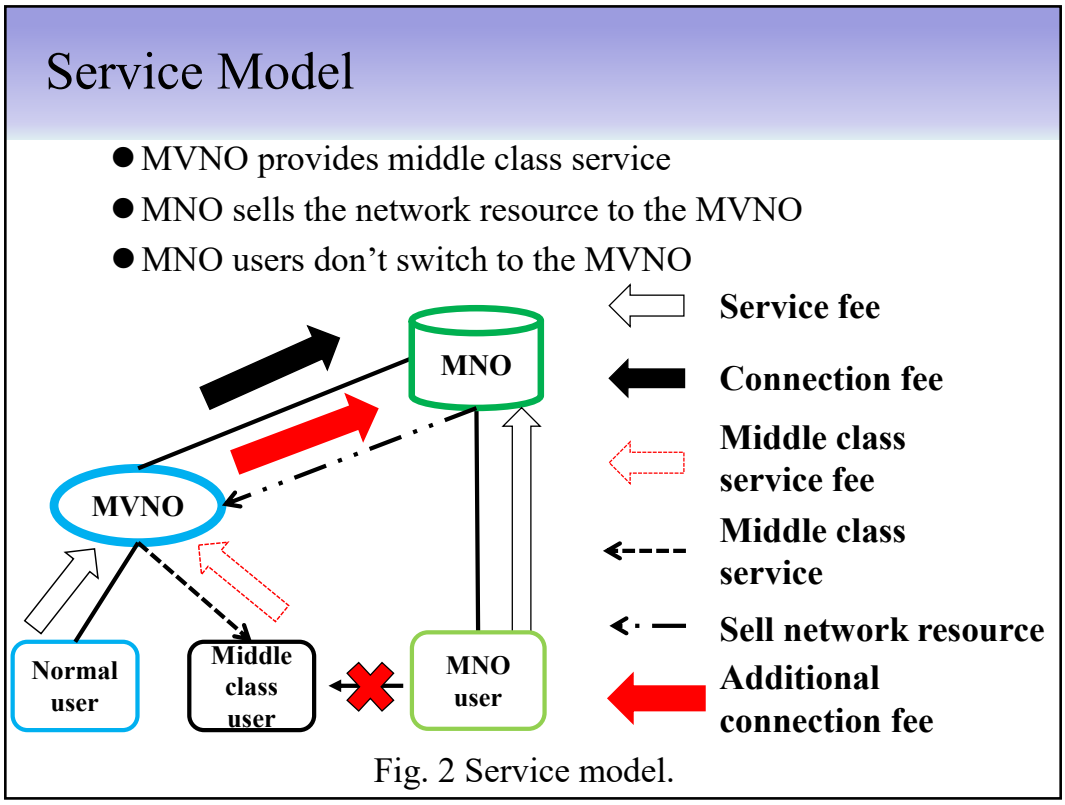


Fig. 2 Service model.

3. Medium Service Quality Model

3.1 Model Design

There are MVNA and MVNE in addition to MNO and MVNO for operators involved in mobile communication services. MVNA resells MNO's resources to small MVNOs. Likewise, MVNE resells MNO's resources to small MVNOs, but MVNE also serves as MVNOs. MVNA is a kind of MVNE. Figure 2 shows the service model considered in this paper. We do not consider MVNA and MVNE in this model, we only consider MNO and MVNO. In Figure 2, it is assumed that the MNO lends the network resource to the MVNO and the MVNO provides the middle class service by utilizing the network resource reselled. Both normal service and middle class service are assumed to be monthly flat-rate service with best-effort quality, and it is assumed that the mean transmission rate and service fee are different. MNO users can use the communication service by paying monthly flat-rate fee to MNO. It is assumed that the MNO users are not satisfied with the middle class service provided by the MVNO and do not switch to the MVNO. MVNO users select either normal service or middle class service. Since MVNO does not have sufficient network resource to provide middle class service with the network resources reselled up to now, it pays additional connection fee to MNO for reselling more network resource. Therefore, MNO's revenue will increase due to additional connection fee received from MVNO.

User's Behaviour Model

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

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

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

  - User's utility depends on the willingness to pay(WTP) (3)
    - $W(s)=a \times s^{\beta}$
- User selection probability based on Binary Logit Model

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

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

3.2 User's Behaviour Model

In this paper, we model the service selection behaviour of MVNO users with a Binary Logit Model [7]. This model is commonly used when modeling user's behaviour. The subscript 1 represents the selection of normal service and the subscript 2 represents the selection of middle class service. If willingness to pay function is $W(s)$, the MVNO normal service fee is c_1, the middle class service fee is c_2, the mean transmission rate of MVNO normal service is s_1, and the mean transmission rate of middle class service is s_2, the user's gain U_1 of choosing normal service and the user's gain U_2 of choosing middle class service can be expressed as the following Eq. (1) and (2).

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

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

Willingness to pay is the amount of money that a user would like to pay for a certain service. Then, it is defined by the following Eq. (3) [8].

$$W(s) = 1500 \times s^{0.3} \quad (3)$$

Assuming that the probability that the user selects normal service is P_1 and the probability that the user selects middle class service is P_2, they are respectively expressed by the following Eq. (4) and (5).

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

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

MNO and MVNO Revenue Model

- MVNO's Expected Revenue

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

- MNO's Expected Revenue

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

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

3.3 MNO and MVNO Revenue Model

Even though there are two types of pricing scheme, flat-rate pricing schemes and usage-based rate pricing scheme, we only consider a monthly flat-rate pricing scheme in this paper. And we derive the optimum price for the flat-rate pricing scheme.

Assuming that the number of MVNO's users is n_1, the number of MNO's users is n_2, the normal service fee of MNO is c_3, and MVNO shares its total revenue of proportion b with MNO as the connection fee. Then, MVNO's expected revenue $E(R_1)$ and MNO's expected revenue E(R_2) are given by the following Eq. (6) and (7), respectively.

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

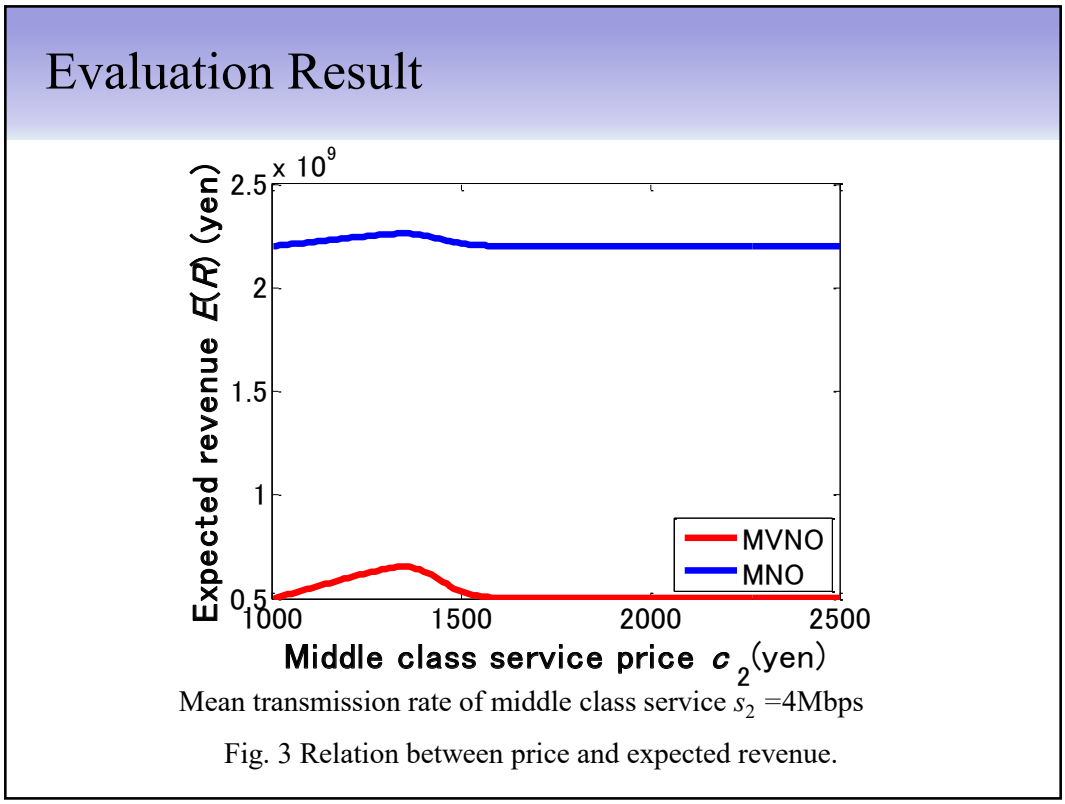
$$E(R_2) = n_2 \times c_3 + b \times E(R_1) \quad (7)$$

From Eq. (6) and (7), it can be seen that maximizing MVNO's expected revenue also maximizes MNO's expected revenue. We need to choose optimal middle class price c_2 to maximize MVNO's expected revenue as shown in Eq.(6).

4. Numerical Evaluation

4.1 Parameters Setting

Table 4 shows parameters setting. In this paper, both the number of MVNO users n_1 and the number MNO users n_2 are 500,000, the normal service fee c_1 of MVNO is 1000 yen, the normal service fee c_3 of MNO is 4000 yen, the mean transmission rate s_1 of MVNO normal service is 2 Mbps, the mean transmission rate s_2 of middle class service of MVNO is 7 Mbps. We set the ratio b of connection fee to MNO to MVNO's revenue to 0.4.

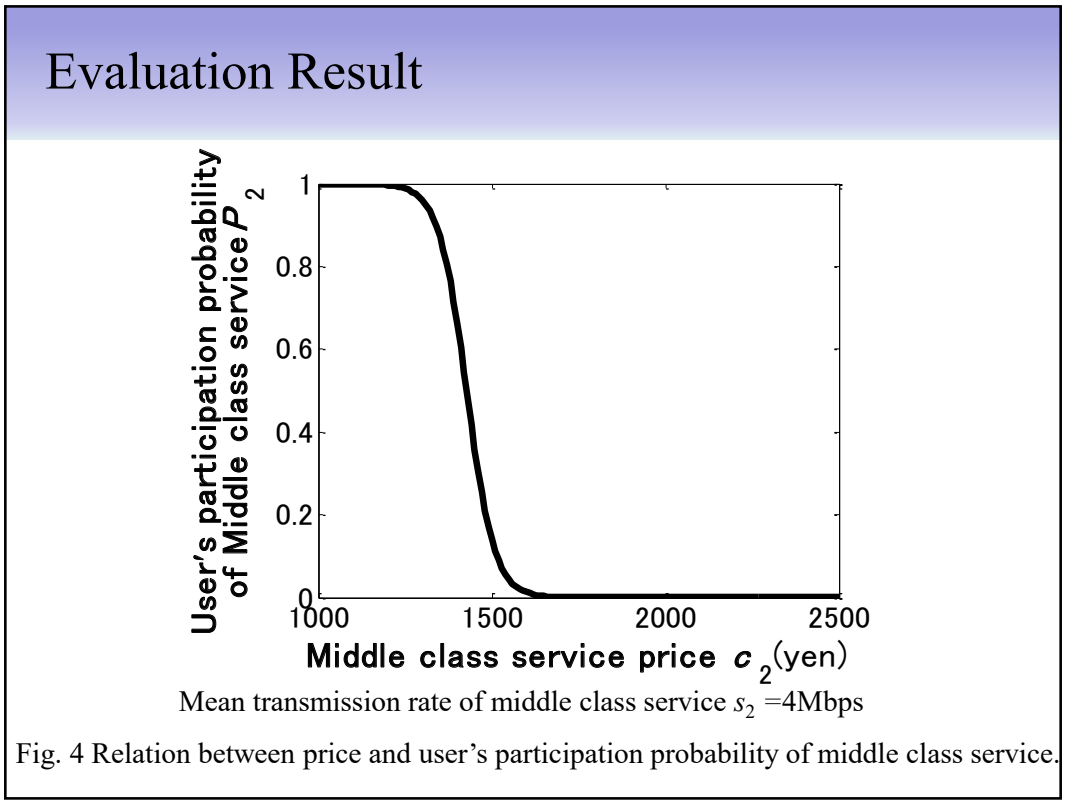


Mean transmission rate of middle class service s_2 =4Mbps

Fig. 3 Relation between price and expected revenue.

4.2 Evaluation Result

Figure 3 shows the relationship between the expected revenue and MVNO middle class service price when the mean transmission rate s_2 of MVNO middle class service is 4 Mbps. When c_2 is 1,350 yen, MVNO's expected revenue E (R_1) is maximized. At the same time, MNO's expected revenue E (R_2) is also maximized since MNO obtains additional connection fee from MVNO.

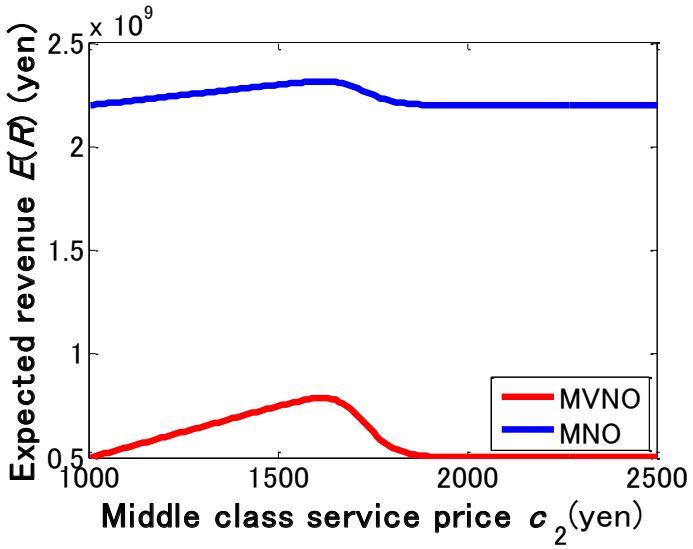


Mean transmission rate of middle class service s_2 =4Mbps

Fig. 4 Relation between price and user's participation probability of middle class service.

Figure 4 shows the relationship between the MVNO middle class service participation probability and the MVNO middle class service price when the mean transmission rate s_2 of MVNO middle class service is 4 Mbps. When c_2 is 1,350 yen, the probability P_2 of participating in MVNO middle class service is 0.872. In addition, in the case where it is desired to make participation in the middle class service 1/9 of the number of users from the relation of the network resource, if c_2 is set to 1,510 yen, the probability P_2 of participating in MVNO quality service becomes 0.111, and efficient band utilization is possible.

Evaluation Result



Mean transmission rate of middle class service s_2 =6Mbps

Fig. 5 Relation between price and expected revenue.

Figure 5 shows the relationship between the expected revenue and MVNO middle class service price when the mean transmission rate s_2 of MVNO middle class service is 6 Mbps. When c_2 is 1,610 yen, MVNO's expected revenue E (R_1) is maximized. At the same time, MNO's expected revenue E (R_2) is also maximized since MNO obtains additional connection fee from MVNO.

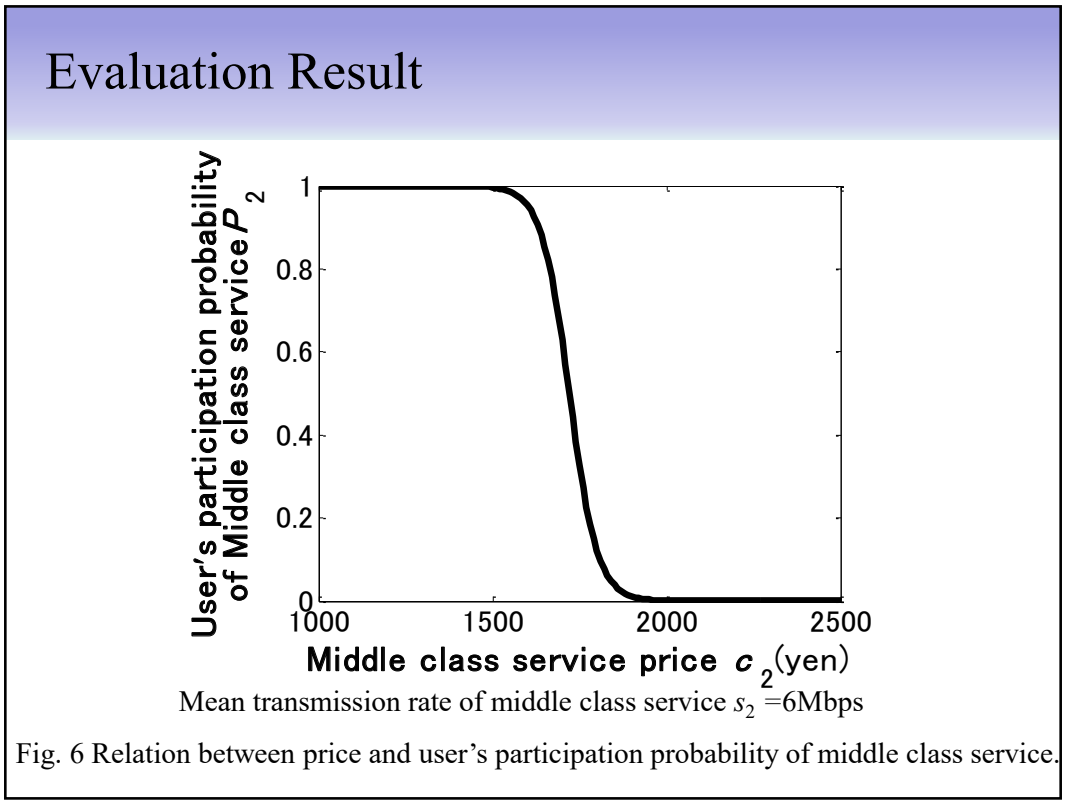
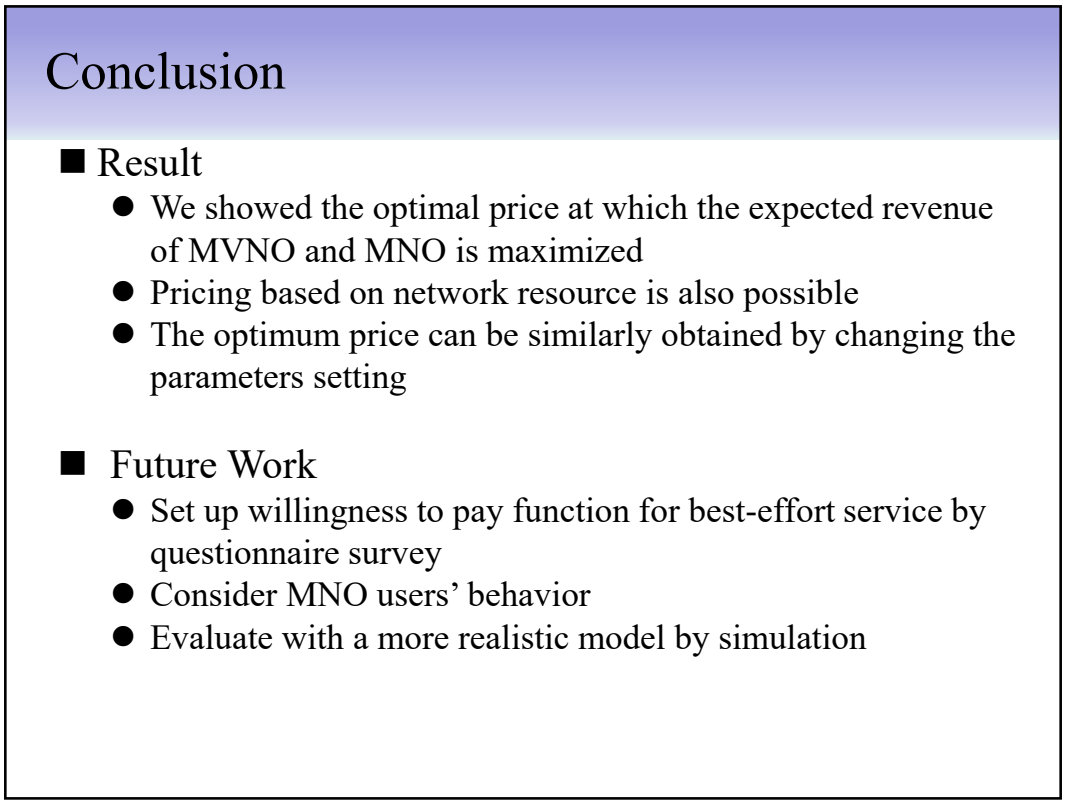


Fig. 6 Relation between price and user's participation probability of middle class service.

Figure 6 shows the relationship between the MVNO middle class service participation probability and the MVNO middle class service price when the mean transmission rate s_2 of MVNO middle class service is 6 Mbps. When c_2 is 1,610 yen, the probability P_2 of participating in MVNO middle class service is 0.941. In addition, in the case where it is desired to make participation in the middle class service 1/2 of the number of users from the relation of the network resource, if c_2 is set to 1,720 yen, the probability P_2 of participating in MVNO quality service becomes 0.505, and efficient band utilization is possible.



5. Conclusion

In this paper, we evaluate the effect of introducing middle class service on the revenue of MNO and MVNO. We did not consider the case where MNO user switch from MNO to MVNO, but we think that the number of MNO users switch to MVNO will increase as the mean transmission rate of middle class service approaches the mean transmission rate of MNO service. As our future works, it is necessary to consider MNO users' behavior. In addition, we need to set up willingness to pay function for best-effort service by questionnaire survey, and to take into account the competition between MVNOs and MNOs. This paper is flamework study. Next step, We Evaluate with a more realistic model by simulation.

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