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# Value Chain Flexibility with RFID: A Case Study of the Octopus Card

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***Abstract:*** *Octopus cards are an electronic payment system based on a wireless RFID technology developed in Hong Kong. Users simply hold their contactless smartcards over an electronic reader, and the payment is deducted from the card automatically. If users link their cards to their credit card to upload money, there is no cash transaction involved. Launched in 1997, Octopus cards are the world's most widely accepted contactless RFID electronic payment system. The system generates value for customers, service providers, and societies.*
*This article makes a theoretical and applied contribution to our understanding of strategic information systems. It adopts and modifies Porter's value chain and develops value-chain flexibility as a theoretical framework to analyze the Octopus card system. The fast and dramatic changes in customer needs, business competition, and technological innovation are creating an urgent need for flexibility throughout the whole value chain. By looking at order fulfillment as a process, the shop outlet—either online or offline—is only part of the entire flow from customer enquiry to customer receipt. It is clear that no single idea could significantly reduce customer lead time. Only a total effort from organizations to increase flexibility and eliminate bottlenecks can make the kind of difference needed to compete (Day, 1994; Blackburn, 1991; Yusuf, Sarhadi, & Gunasekran, 1999). Therefore, value chain flexibility must be broadly defined, and it should be applied in the service industry. In other words, organizations should be able to deal with the uncertainty along the value chain to meet customer demands. This framework analyzes how the Octopus card system creates value and, in doing so, identifies key implications for customers, service providers, and society*
***Keywords:*** *Strategic Information Systems, Value Chain Flexibility, RFID Technology, Electronic Payment*

## 1. Introduction

Octopus cards are a part of an electronic payment system that uses a contactless smartcard with RFID technology. Users simply hold their electronic card over a reader, and the exact amount is deducted from the card automatically. The Hong Kong transportation system uses Octopus cards. In 2010, an average of 11 million passenger journeys were made throughout Hong Kong on a wide variety of modes of public transport everyday (Octopus, 2010). To handle this consistently heavy traffic, the MTR Corporation Limited (MTR) has been operating a fully automatic fare collection system since 1979. Initially, cards were recycled magnetic plastic cards principally used for single journeys and stored-value tickets good for 10 trips. The cards allowed riders to enter and exit the transport area.

In 1993, the MTR took the lead in reviewing its fare-collection technology and studying a future development strategy for the next decade. In 1994, MTR decided that contactless smartcard technology was the best solution for customers' future demand. MTR chose Creative Star Limited (renamed Octopus Cards Limited in 2002), a joint venture with a number of public transport operators, to develop and implement the system. The Octopus smartcard system was officially launched in 1997, allowing users to use a single card for travel across different modes of transportation.

Nowadays, Octopus services are available for nearly all of Hong Kong's transport modes. They can also be used for parking meters, car parks, convenience stores, fast food outlets, supermarkets, and household and personal care stores, as well as access control for residential and commercial premises (Octopus, 2010).

Leveraging the success of the Octopus card in Hong Kong, Octopus China Investments Limited and Octopus International Projects Limited have been established to tap into business opportunities that can utilize Octopus's experience and skills in smartcard systems in Mainland China and other countries (Octopus, 2010). With full co-operation between the Hong Kong Government and Shenzhen offices, Octopus is now accepted at over 10 outlets operated by Café de Coral and Fairwood fast food restaurants in Shenzhen, as well as at the Shenzhen Dutyfree Group's outlets at Huanggang Port and Luo Hu Port. Both sites are working to add more applications (Octopus, 2010).

Octopus shared its special design technology and experience with the Netherlands and Dubai in 2003 and 2007 respectively (Octopus, 2010). The Dutch public

transport e-ticketing system developed and supported by Octopus was launched in Rotterdam and Amsterdam in 2009 and has been extended to the whole country. In 2009, Octopus developed the Dubai smartcard payment system for various modes of public transportation (Octopus, 2010).

This paper uses a case study to understand the economic effects of the Octopus system and the Octopus electronic payment system to understand value chain flexibility. M.E. Porter introduced value chains as a systematic approach to examine the development of competitive advantage (Porter, M., 1980). The chain consists of a series of activities that create and build value in different stages. Moreover, the value-chain model serves as a useful analytical tool for service industries, particularly in rapidly changing information technology environments (Olla, P. & Patel, N., 2002). Thus, this paper describes the value chain of the electronic payment system with RFID technology. It describes the value created for core players at each stage.

## 2. Background of Electronic Payment

Electronic payment (ePayment) refers to a person or an institution sending a sum of electronic money to settle a payment. For example, a customer can pay in a convenience store using an Octopus Card.

Electronic payment methods can be classified by the size of the amount to be paid. Three categories are defined: picopayments, micropayments, and macropayments. Picopayments are payments for amounts less than 1 cent, and they are more suitable for web payment. The micropayment category contains payments for amounts of between 1 to 10 HK Dollars. Payment solutions for larger amounts fall into the macropayment category. However, Octopus cards are used mainly for micropayment and macropayment.

The time of transaction can also be used to classify payment methods. Methods can be categorized as prepaid, pay now, and pay later. Well-known nonelectronic examples are prepayments (for the prepaid category), cash on delivery (for pay now), and invoices (for pay later). Octopus cards are classified as cash on delivery.

Payment methods can also be classified according to the technology employed. Categories can be differentiated by the settlement of accounts and the methods used to store electronic money. This is deposited into an account or stored in the form of virtual coins in software or hardware. Octopus cards are one kind of stored electronic money.

Payment methods differ in terms of the degree of anonymity. Paying with nonelectronic cash is considered an anonymous transaction. In contrast, Octopus payments are not anonymous because the seller knows the identity of the buyer. However, sellers cannot identify buyers if buyers use nonpersonal Octopus cards.

### *2.1. Credit Card*

Credit cards are a very popular means of ePayment. Larger macropayments are usually paid with a credit card. To ensure that only the online trader receives this number, it is transmitted over a secure line. Over the last few years, the use of credit cards over a secure sockets layer- (SSL) encoded connection has established itself as a means of ePayment. The SSL protocol is available in most browsers and provides an encoded connection between the client and server. The popularity of credit cards can be explained with the following major reasons:

- Credit card technologies are mature and have been in use for decades in offline trading.
- Credit cards are available and accepted worldwide.
- Credit cards are not complicated to use. The online payment simply involves entering the credit card number along with the name of the card owner into a form.

However, credit cards also have some disadvantages:

- Credit cards do not have any security mechanisms. If an attacker steals a credit card number, this is sufficient to buy products online.
- Credit cards are not anonymous. When a credit card owner uses it, both the seller and the bank learn its number, causing a security risk.
- The handling charges for credit cards are relatively expensive for sellers. Credit card institutions and banks require the seller to pay commission charges and a percentage of sales.

### *2.2. PayPal*

In contrast to the direct use of credit cards described above, PayPal makes payments between two individuals parties. For a long time, this US-based company only offered accounts in US dollars, but it has recently backed other currencies, such as Euros and British pounds.

In order to be able to use PayPal, customers have to register online. PayPal is based on credit cards and bank accounts. Newly registered users enter their credit card information but cannot use PayPal until their account has been activated. PayPal subsequently debits a small amount (normally $1) from the credit card entered. The description of this deduction on the credit card statement contains a number. Users then send this number to PayPal to activate the account. This method makes it difficult to register a stolen number with PayPal, since thieves normally have no access to the credit card account. Once users successfully register, they can then carry out transactions with other PayPal members.

Like credit cards, PayPal is not complicated to use. If a buyer wants to buy a product from a seller, the seller needs to send the necessary payment information to the buyer first. Included are the amount to be paid and the account name, which corresponds to an email address. The buyer then logs into the PayPal system and enters the payment information received into a form. PayPal debits

the buyer's credit card or bank account and sends the amount in electronic money to the seller.

*2.3. Octopus Card System*

Octopus cards contain electronic microchips that store and update payment information and monetary value. When a customer uses it, the card is scanned by an Octopus reading processor, which deducts the transaction amount from the card. The operation mode is consistent in all payment transactions (Octopus, 2010).

Fig. 1 illustrates the system architecture of the Octopus system. The Octopus Clearing House (OCH) is the core component of the system that is responsible for transaction validations, revenue allocation, and fund transfers (Octopus Cards Limited, 2005d; Chau, P. & Poon, S., 2003). The front-end smartcard processors are the reader machines that users interact with directly. Processors can communicate with the central computer or database in real-time, although certain readers store transaction data offline and send them through the network later (Wikipedia, 2008).

*2.3.1. Types of Octopus Cards*

There are three major types of Octopus cards: on-loan Octopus cards (for children, adults, the elderly, and personalized types), sold Octopus cards, and bank-issued Octopus cards. On-loan cards are cards that a company rents to customers who pay in advance a refundable deposit that covers the associated costs and a negative value allowance. Sold cards are specially designed cards that the company sells to customers. They hold no deposit. Bank-issued cards are issued by authorized banks and financial services companies (Octopus, 2010).

*2.3.2. Features of Octopus Cards*

The followings are the major features of Octopus cards:

- Efficient and accurate: simplifies cash counting, reducing human counting mistakes and time required for bank arrangements.
- Multi-usage with one single card: services ranging from transport, parking, retail, self-service business, leisure facilities, and access control.

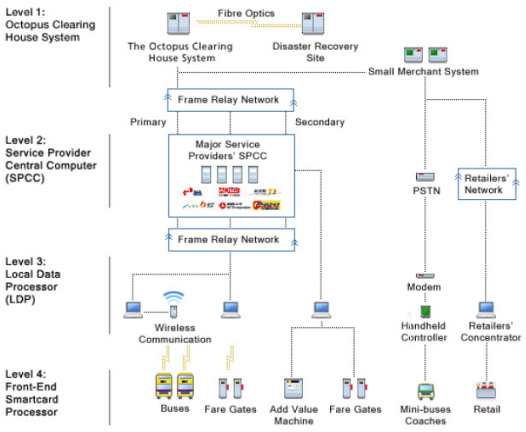


Fig. 1. The system architecture of the Octopus system

- Easy reloading: numerous reloading points and a wide range of reloading channels, including Octopus's automatic add value service by credit card and bank accounts.
- Cost saving: reduces the cost of handling cash.
- Convenient and fast: eliminates the need to carry cash or exact fares. Carries out transactions in as fast as 0.3 seconds.
- Secure and reliable: high reliability and accuracy with comprehensive measures in place to safeguard the integrity and security of the system.

*2.3.3. Octopus Card Technology*

The Octopus system is a major innovative breakthrough in smartcard payment technology. Since its launch, Octopus cards have undergone many developments, gaining a major achievement of integrating the Octopus card clearing house system with the systems of a wide variety of companies and merchants offering Octopus cards.

Octopus cards have built-in integrated circuit chips that communicate with different fare processors through the use of an Octopus card reader/writer. The reader/writer is made of a controller board and an antenna. It uses inductive radio frequency coupling to transmit power and data signals to the processors inside the contactless smartcard. The maximum operating range of the reader/writer is about 100mm. A reader/writer is connected to each Octopus card processor and receives commands from the processor controller on the actions to be performed. The transaction data is then either stored in the reader or sent back to a host computer, depending on whether the processor is online or offline.

The Octopus clearing house system uses a complex set of business rules to validate each transaction prior to authorizing settlement amounts. A standard set of reports is then sent to each participating service provider on a daily basis, and the settlement amounts are deposited into their accounts within 24 hours.

*2.3.4. Octopus Achievements*

Since its launch in 1997, the Octopus system has reached the following achievements (Octopus, 2010):

- It has the world's highest acceptance rate of a commercial smartcard system. Nearly 95% of Hong Kong citizens from age 16 to 65 possess an Octopus card.
- It is the world's most-used smartcard system, with over 11 million transactions a day, valued at over HK$100 million.
- It has the world's widest scope of applications, with more than 9,000 retail outlets from over 3,000 service providers from a wide range of sectors. New uses for Octopus cards are regularly being added.
- It has attracted a considerable number of delegations from all over the world that visit to learn about the Octopus card system, facilitating industry development.

## 3. The Value Chain

A value chain describes a series of activities that organize operations in an industry. The business unit in an organization is the appropriate level for construction of a value chain. Products pass through all activities of the chain in order, and at each activity the product gains some value. The chain of activities gives the products more added value than the sum of added values of all activities that can generate the competitive advantages for the company.

In general, value chains describe the generic value-adding activities of an organization. The primary activities include inbound logistics, operations, outbound logistics, marketing and sales, and services. The support activities include administrative infrastructure management, human resource management, technology, and procurement.

Capturing the value generated along the chain is the new approach taken by many management strategists. For example, a manufacturer might require its suppliers to be located near its assembly factory to minimize the cost of delivery. For example, by exploiting the upstream and downstream information flowing along the value chain, the firms may try to bypass the intermediaries to create new business models.

The integrated process framework guides the modeling, design, and measurement of business performance by uniquely encompassing the plan, government, and execution requirements for the design, product, and customer aspects of business. Porter, M. states that ''the value chain disaggregates a firm into its strategically relevant activities in order to understand the behaviour of costs and the existing and potential sources of differentiation" (1985, p. 33). Value is defined as being what buyers are prepared to pay for a product, coming either from being a cost leader or by obtaining premium prices through differentiation.

An individual organization's value chain is connected to the value chains of both its suppliers and buyers, in what are termed 'value chain systems.' Its suppliers provide inputs to the firm's value chain while the output of the firm's own value chain creates inputs for its buyer's value chains. In related work, Porter, M. and Millar, V., (1985) suggested that IT was transforming the value chain in terms of the individual activities and also the linkages between activities.

Rayport, J. and Sviokla, J., (1995) argue that, alongside the value chain, there is a virtual value chain that can create new value. An example of this is letting users access marketing information online, something that is costly when done manually. Rayport and Sviokla further state that some activities can be moved from the physical value chain to the virtual value chain. Although Porter's value chain has been seen as a useful tool in analyzing traditional industries, particularly manufacturing, its relevance to the service sector has been questioned (Peppard, J. & Rylander, A., 2006).

## 4. Value Chain Flexibility

Increasing global competition, accelerating technological change, and demanding customers are creating a more turbulent, complex, knowledge-intensive, and uncertain environment (Huber, G., 1984; Skinner, W., 1995; Doll, W. & Vonderembse, M., 1991). In response, manufacturers are trying to increase flexibility as they strive to compete in the 21st century. Flexibility enables firms to design, produce, and deliver a wide variety of high-quality, low-cost products quickly. Therefore it is strategically important as an order-winning criterion (Gerwin, D., 1993; Upton, D., 1995; Hill, T., 1994; Jordan, W. & Graves, S., 1995). Only as flexibility is added to total-quality management capabilities and productivity improvement efforts can manufacturers be successful in highly competitive global markets.

Under global competition, organizations need to make improvements to their responsiveness to customer needs for better quality and lower cost to compete with their competitors. To be more competitive, service industries should add flexibility to their customer-valued competitive capabilities. Flexibility enables organizations to meet a variety of customer needs without additional cost, time, organizational disruption, or loss of quality. Therefore, flexibility is regarded as a source of competitive advantage (De M. et al., 1989). Gunasekaran , A., (1999) and Yusuf, Y. et al., (1999) advocate flexibility and agility as the paradigm for 21st century manufacturing and service industries.

The concept of flexibility appears widely in manufacturing literature (Geerwin, D., 1987; Hayes, R. & Wheelwright, S., 1979; Hill, T., 1994). The past two decades' emphasis on the strategic role of manufacturing set the stage for research on manufacturing flexibility. From a strategic perspective, Skinner, W., (1969) claims that manufacturing is the missing link in corporate strategy and that firms integrating manufacturing strategy with corporate strategy can achieve a competitive advantage. He promotes building a flexible and learning organization by using flexible technology and management techniques (Skinner, W., 1985). Hayes , R. & Wheelwright, S., (1979) incorporate flexibility in discussing the product-process matrix as a tool to coordinate the interface of marketing and manufacturing to achieve unified corporate goals. Wheelwright, S. & Hayes, R., (1985) define a hierarchy of manufacturing strategies (i.e., internal neutral, internal support, external neutral, and external support) along the reactive proactive use of flexible technology. Hill, T., (1994) describes a manufacturing strategy model including flexibility as an order winner or order qualifier. Upton, D., (1995) defines flexibility as increasing the range of products available, increasing a firm's ability to respond quickly, and achieving good performance over the range of products produced. Although these authors have made great efforts to define and measure flexibility, there

is no unified concept that is widely accepted. Many questions about flexibility remain unanswered in service operation.

In order to deal with environmental uncertainty, organizations have two ways to balance the demand and supply: (1) inventory and (2) flexibility in the value chain, which allows the company to alter the activity rate on the factory floor so as to satisfy the demand fluctuations without severe disruption. Because it is well accepted that large inventories hide problems and raise costs, firms seek another way to cope with uncertainty: value chain flexibility. Value chain flexibility is defined as the ability of the organization to deal with internal and external uncertainty along the value chain to meet the desired demands quickly and perform effectively.

Nowadays, the fast changes in customer requirements, marketing competition, and innovation create a strong demand for flexibility across the whole value chain in service industries. By looking at order fulfillment as a transaction, the retail outlet is only part of the entire flow from customer enquiry to customer order. It is clear that no simple method can significantly improve customer experience. Organizations' effort to increase flexibility and eliminate barriers could make the kind of difference needed to compete (Day, G., 1994; Blackburn, J., 1991; Yusuf, Y. et al., 1999). Therefore, value chain flexibility must be broadly defined, and it should include service industry value chain flexibility.

## 5. Analysis of Octopus Cards in Value Chain Flexibility

With innovative smartcard technology, the Octopus card system improved user transaction time in various applications (Chau, P. & Poon, S., 2003). Previously, 60 tons of coins were collected on a daily basis, which cost as much as 0.8% of revenue to collect and count. The user-friendliness of Octopus increased usage and revenue over time, and it decreased maintenance costs (Octopus, 2010).

Given Octopus's wide acceptance and popularity, it eventually evolved into a process of enabling quicker payment transactions for goods and services as well. It was expanded to a large number of services outside of transportation; now over 2,000 services accept Octopus. Retailers are able to implement the system easily and inexpensively by economies of scale through a shared system infrastructure (Octopus, 2010).

The value chain is the full range of activities that are required to bring a product from its conception to its end use. This consists of activities such as design, production, marketing, distribution, and support to the final consumer in service industries. The reconfiguration of the value chain of the Octopus card system consists of four parts: scanning, networking, transaction, and acting stages. Each stage has its own service demands, customer needs, technical requirements, and business standards.

In the scanning stage, it is essential to have an accurate and user-friendly scanning technology. Through advanced and reliable RFID technology, customers can scan their Octopus card at the reader quickly.

In terms of networking, the Octopus card system is connected to the banking system, commercial operators, and clearing centers with high speed on a secure network in Hong Kong. Privacy and security are critical for customers. A network service provider provides wireless sensor networks, and a PKI service provider supports a high-level encryption and decryption algorithm for the protection of transaction information.

The third stage is the transaction stage. Customers demand that the data collected by merchants be correct and high-quality. The speed and convenience of using electronic money are also central requirements for customers.

The last stage is an acting stage, which is the reaction and control between customers, merchants, and the Octopus Card Company. The reliable clearing system can be the core player for this stage.

In the value chain of Octopus cards, they keep their flexibility and generate value for customers, service providers, and society summarized as follows:

### *5.1. Value to customers*

- Convenient
- Reliable and secure payment method
- Flexible recharging/reloading methods
- One card for a wide range of applications
- Discount and loyalty schemes

### *5.2. Value to service providers*

*Operational Benefits*

- Secure, efficient, flexible, and reliable means of revenue collection
- Shorter transaction time
- Reduced faulty magnetic plastic card handling
- Peripheral internal uses such as staff ID and access control

*Financial benefits*

- Reduced cash handling
- Increase in usage and revenue through enhanced system user-friendliness
- Improved revenue protection through greater security by minimizing fraud and capability to block transactions after card loss
- Elimination of card recycling costs, since Octopus is reloadable
- Economies of scale achieved by sharing a common system infrastructure by all participating organizations

*Business benefits*

- Provision of a platform accommodating complex fare collection strategies such as internal discounts and loyalty schemes
- More management data on customer profiles and behavior for service improvement
- Enhanced corporate image and customer service

*5.3. Value to society*

- The system can be considered a major step towards a cashless society
- Compared to coins, the Octopus is more hygienic, convenient, and fast
- The polyethylene terephthalate (PET) material used to make the card is environmentally friendly. The card is reloadable without creating waste

**6. Conclusion**

The value chain flexibility model is mainly used in manufacturing industries. This article has offered insights into RFID applications in service industries by adapting the value chain flexibility model. The reconfiguration of the value chain of the Octopus card system consists of four parts: scanning, networking, transaction, and acting. Each stage has its own service demands, customer needs, technical requirements, and business standards. The Octopus electronic payment smartcard system creates value for service industries, customers, service providers, and society.

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