

ANALYZING IMPACT OF INTERFACE IMPLEMENTATION EFFORTS ON THE STRUCTURE OF A SOFTWARE MARKET

OSS/BSS Market Polarization Scenario

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Abstract: A vertical software market is usually subject to the process of disintegration resulting in a market where different layers of software are provided by independent software vendors. However, as argued in this paper, the process of this vertical disintegration may be affected by high investments to software interface implementation and maintenance. Should the required efforts be large, the threshold for entering the market increases, thereby hampering the vertical disintegration process. This study examines the impact of the interface implementation efforts on the vertical market evolution in the case of the so-called operations support systems and business support systems (OSS/BSS) software, which are employed by the telecom operators in order to support their daily operations. The efforts are compared for two prototypical software vendors serving incumbent operators and new operators respectively. Total efforts are an order of magnitude larger in the former case. Furthermore, even if only latest network protocols are taken into account, the efforts are significantly larger in the former case, therefore requiring several times greater number of employees to implement them. Therefore, a conclusion is made that the OSS/BSS market is likely to polarize into the vertical submarket of large software vendors serving incumbent operators, and the submarket of small vendors serving young operators. The latter submarket, due to the lower entry threshold for new vendors is more likely to be vertically disintegrated.

1 INTRODUCTION

Software markets generally develop from vertically integrated towards vertically disintegrated (Macher and Mowery, 2004). According to the model based on the analysis of different verticals of the Finnish software industry (Tyrväinen et al., 2004, 2008), for instance, innovative software is initially developed not by software vendors but in house by companies representing the business in the market vertical in order to automate and improve their business processes and thereby achieve competitive advantage over the competition in the specific industry. Vertical disintegration implies that the software is decomposed into horizontal layers; software in different layers is provided by independent software vendors and it is integrated

with the other layers via standardized interfaces. Numerous vendors operate horizontally in multiple industries, which provide a larger market for them while some of vendors are still specialized to serve a single industry.

Several factors such as high degree of customer-specific tailoring, the need to coordinate innovation efforts spanning over several layers in a vertical (Mazhelis et al., 2007), etc., are likely to hamper the vertical disintegration of the software. In this paper, we focus on studying another potential hindering factor, namely, the high complexity of the software interfaces. We assume that, whenever a software vendor provides software to a customer, this software needs to be integrated with a number of heterogeneous subsystems deployed by the customer. If the number of integration interfaces is

high, a vast amount of special knowledge is needed in the vendor organization. High integration efforts consume also the limited amount of competent employees of the vendor organization decreasing the number of customers which it is capable to serve. As a result, only few large vendors can survive in such market, and the evolution towards horizontalized market with standardized interfaces and established standard architectures (see e.g., dominant design in Murmann and Frenken 2006) may be delayed or may never materialize.

The impact of the software interface implementation efforts on the structure of the market is studied in this paper on the example of the telecom operator software. The so-called operations support systems and business support systems (OSS/BSS) are used by the telecom operators for operating and monitoring their networks, as well as for managing their performance, quality of service, faults, configuration, roaming, accounting, customer relationships, frauds, etc. (Terplan, 2001). Though the OSS/BSS software has been used for several decades, the software still remains to a large extent vertically integrated. E.g. activation and configuration software, performance and fault management software is often produced by the vendors of network element hardware.

In this paper, we study whether the high complexity of the OSS/BSS software interfaces may serve as a potential hindering factor for OSS/BSS market horizontalization. We assume that OSS/BSS software provided by a software vendor for an incumbent operator needs to be integrated with a large number of heterogeneous subsystems. Due to the high interface implementation efforts, the number of companies capable of providing necessary integration decreases, and hence the OSS/BSS market horizontalization may be delayed.

Based on the above assumption, a hypothesis is made that the OSS/BSS market will split into the submarket of incumbent operators with vertically integrated systems, and the submarket of new operators with vertically disintegrated systems. Consequently, the OSS/BSS market is likely to be polarized into many smaller players and few very big players, serving two distinct types of customers – respectively incumbent and new operators.

In order to verify the hypothesis, the interface implementation efforts for incumbent and new operators are compared in the paper. For this, interface implementation efforts for the activation and billing mediation segments are estimated. It is found that the efforts needed for new operators are significantly lower as compared with the efforts

required for the incumbents. As a result, a tentative conclusion is made that the vertical disintegration is more likely in the domain (submarket) of young operators, and consequently, OSS/BSS market is likely to become polarized into many small and few very big software vendors.

The paper is organized as follows. In the next section, an approach to interface implementation efforts estimation is introduced. This approach is applied in section 3, in order to assess and compare the efforts of implementing OSS/BSS mediation interfaces. Some business implications of the results of this study are provided in section 4, followed by the conclusions in section 5.

2 INTERFACES AND THEIR IMPLEMENTATION EFFORTS

In order to verify the hypothesis that the process of market horizontalization may be hindered due to the set of interfaces which need to be supported, we consider the efforts which a software vendor needs to devote to interface implementation and maintenance. The effort estimations are employed as an indicator reflecting the likely size of the software vendors capable of providing these interfaces. Higher interface implementation efforts resulting in the greater size of the software vendors are assumed to reduce the number of software vendors in the market, and hence delay the horizontalization of the market. Furthermore, horizontalization in two submarkets can be compared on the basis of the interface implementation efforts: the greater the efforts, the more likely delays in the horizontalization. Eventually, the submarket with the lighter interface implementation efforts may horizontalize while the submarket with greater efforts may remain vertically integrated, thereby resulting in a market polarization.

In this paper, an *interface* is defined as a stack of protocols and associated data formats that govern a communication between software subsystems. Protocols in the stack may have different versions; two interfaces comprised of the same protocols of distinct versions are referred to as *variations* of the interface.

Given an interface to be supported, human resources are required not only to implement or configure the software providing the interface, but also afterwards – for maintenance, for reconfiguration of a standardized interface, or in order to perform new integration projects involving

the interface. Therefore, human resources are needed for each interface for the entire lifetime of that interface.

Below, the approach to estimating interface implementation efforts is described, and the OSS/BSS interfaces that are being analyzed are introduced.

2.1 Estimating Interface Implementation Efforts

Let us consider the total efforts a software vendor devotes to interface implementation, namely:

- The initial implementation of interfaces (i.e. initial implementation of protocol stacks),
- The development of the new variations of interfaces (corresponding to new versions of protocols),
- Configuration of the interfaces for individual customers (mainly data format are adapted to the needs of an individual customer),
- Maintenance of interfaces.

The efforts needed for implementing an interface greatly depend on the type of protocols being used. Many types of protocols may need to be implemented, among them are proprietary, OSI based (FTAM, CMISE/CMIP), CORBA, web-based (HTTP, SOAP, LDAP, RADIUS), and other standards-based protocols (FTP, GTP, MAP, etc.). Besides, protocols may have several versions, hence resulting in a number of coexisting interface variations.

In order to assess the total interface development and maintenance efforts, we need to first determine:

- for each type of protocols, the number of versions/variations;
- for each variation, the efforts (initial, variant development, configuration, maintenance) needed.

The above estimates need to be time-stamped, so that the year-by-year dynamics of the efforts could be studied.

For each interface, by consulting publicly available data and by inquiring domain experts, the main types of the protocol stacks and the number of protocol variations can be determined, and the efforts needed for each of the variations may be estimated. The number of protocols and their variations are calculated as follows.

The number of new standard protocols $N_{new\ std}$ of a specific type is equal to 1, if the protocol has

adopted during the specified period of time, and is equal to 0 otherwise.

The number of new proprietary protocols $N_{new\ propr}$ of a specific type developed within period (y_{start}, y_{stop}) (in years) is estimated as:

$$N_{new\ propr}(y_{start}, y_{stop}) = N_{new\ propr\ per\ year} \times \frac{N_{total}}{\sum_{all\ protocol\ types} N_{total}} (y'_{stop} - y'_{start}), \quad (1)$$

where:

- Y_{begin} and Y_{end} are the beginning and the end of the protocol lifetime, respectively,
- $y'_{stop} = \min(y_{stop}, Y_{end})$,
- $y'_{start} = \max(y_{start}, Y_{begin})$,
- N_{total} is the total number of variations of a specific type of protocols, and
- $N_{new\ propr\ per\ year}$ is the average number of new proprietary protocols being developed each year (assumed to be equal 2 in this study).

It is assumed for simplicity that protocol variations are uniformly distributed throughout the lifetime of the protocol. Then, for each protocol type, the number of protocol variations N_{var} for a given period (y_{start}, y_{stop}) is estimated as:

$$N_{var}(y_{start}, y_{stop}) = \frac{N_{total}}{Y_{end} - Y_{begin}} (y'_{stop} - y'_{start}) \quad (2)$$

It is assumed that development of a new variation also requires configuration, therefore the number of configurations is $N_{conf}(y_{start}, y_{stop}) = N_{var}(y_{start}, y_{stop})$. It is further assumed that all the interfaces require maintenance efforts, which are constant during the lifetime of the protocol, and are decreasing afterwards at the rate negatively proportional to the time elapsed:

$$N_{maint}(y_{start}, y_{stop}) = \int_{y'_{start}}^{y'_{stop}} [N_{new}(t) + N_{var}(t)] dt, \text{ where} \\ N_{var}(t) = N_{var}(Y_{begin}, t) \\ N_{new}(t) = \begin{cases} N_{new}(Y_{begin}, t), & \text{if } t \leq Y_{end} \\ \frac{N_{new}(Y_{begin}, Y_{end})}{1 + (t - Y_{end})}, & \text{if } t > Y_{end} \end{cases} \quad (3)$$

Here, $N_{\text{new}}(y_{\text{start}}, y_{\text{stop}})$ denotes, depending on the protocol, either $N_{\text{new propr}}(y_{\text{start}}, y_{\text{stop}})$ or $N_{\text{new std}}(y_{\text{start}}, y_{\text{stop}})$.

For each protocol type, the total interface implementation efforts e within a period $(y_{\text{start}}, y_{\text{stop}})$ are estimated by summing the initial implementation efforts e_0 , the efforts e_{var} needed for implementing variations, the configuration efforts e_{conf} , and the maintenance efforts e_{maint} :

$$e(y_{\text{start}}, y_{\text{stop}}) = e_0 N_{\text{new}}(y_{\text{start}}, y_{\text{stop}}) + e_{\text{var}} N_{\text{var}}(y_{\text{start}}, y_{\text{stop}}) + e_{\text{conf}} N_{\text{conf}}(y_{\text{start}}, y_{\text{stop}}) + e_{\text{maint}} N_{\text{maint}}(y_{\text{start}}, y_{\text{stop}}) \quad (4)$$

Finally, the total interface implementation efforts for all types of protocols within a period $(y_{\text{start}}, y_{\text{stop}})$ are estimated by summing up the efforts of different types of protocols:

$$E(y_{\text{start}}, y_{\text{stop}}) = \sum_{\text{all protocol types}} e(y_{\text{start}}, y_{\text{stop}}) \quad (5)$$

The estimation of the interface implementation efforts can be then used in estimating the size of the software vendor organization. Namely, assuming a specific percentage of employees devoted to interface implementation efforts, the size of the research and development (R&D) department(s) and the total size of the organization can be estimated.

2.2 OSS/BSS Mediation Interfaces

In order to verify the hypothesis of OSS/BSS market polarization into a horizontal submarket of many smaller players and a vertical submarket of few very big players, we consider the interfaces of their respective customers – i.e. incumbent and new operators.

The assumption is that the “older” the operator, the larger number of heterogeneous subsystems the operator has adopted and has to maintain; this heterogeneity stems e.g. from the mergers and acquisitions, upgrades to new versions and types of equipment, etc. The incumbent operators have highly complex systems composed of a large number of diverse subsystems with complex (also proprietary) interfaces between them. Young operators who may have started with greenfield implementation, on the other hand, are likely to

operate with a more manageable infrastructure with a smaller number of harmonized subsystems where standard interfaces are used more often. Interface implementation efforts differ dramatically among the two.

Another differentiation factor between incumbent operators and young operators is the change of business models. Incumbent operators typically have a lot of business models which are based on billable tickets collected from hardware. Those tickets are then billed based on different agreements with customers – this kind of business model is for example the traditional fixedline PSTN – business. Young operators often base their business on flat rate business models, because the volume’s doesn’t support heavy investments on ticketing based systems. The business model is more or less like any other service business for example like Cable TV –business. This differentiation can be seen in the amount of the interfaces and also in the complexity in the interface structure.

As a result, new entrants (software vendors), who have a rather limited number of personnel available, are likely to be able to cover integration work only in upcoming markets where the integration work is simplified by the use of web-based integration technologies (based on IETF standards) as well as by the use of business process management tools.

There are a number of interfaces present in OSS/BSS systems; however, for simplicity, the analysis in the paper is restricted to the four interfaces, which need to be implemented by the mediation software subsystems (see Figure 1 below):

- Charging
 - Collection interface between Mediation and Network Elements (NEs)
 - Charging interface between Mediation and Billing Systems (also fraud, revenue assurance, dataware, interconnect etc. systems)
- Configuration
 - Configuration interface between Mediation and NEs
 - Activation interface between Mediation and Service Order Management System (e.g. inside CRM, Billing, sales applications)

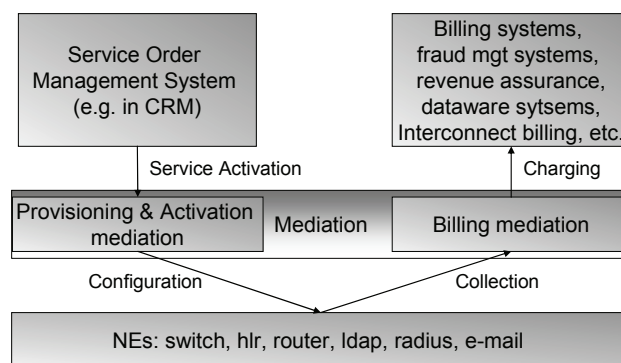


Figure 1: Interfaces implemented by the mediation software.

A product of a software vendor may interface only with a few other types of physical entities (network elements, billing systems, repositories, etc.). However, for each of these interfaces, a variety of application protocols may need to be supported, ranging from proprietary protocols and flat files, to FTP, telnet, CMISE/CMIP, to IETF protocols such as HTTP, SOAP, LDAP, RADIUS etc. The data may be transferred over various network protocols (X.25, TCP/IP or UDP, SS7, etc.) using different data presentation formats (ASN.1, TAP, IPDR, NetFlow records, etc.). Moreover, each of the protocol stacks may have numerous versions resulting in numerous interface variations. As a result, the software vendor may need to develop and maintain hundreds of different interface variations.

3 POLARIZATION OF OSS/BSS MARKET: COMPARING EFFORTS OF INTERFACE IMPLEMENTATION

The data used in this study originates from the SmarTop project (<http://www.jyu.fi/titu/smartop>), which explores the evolution of telecom operator software focusing on the development of the software market in this domain. Various data collection techniques were employed including the analysis of the Dittberner Associates' OSS/BSS Knowledgebase (<http://www.dittberner.com/reports/about53.php>), documentation by TeleManagement Forum (<http://www.tmforum.com/>), and other publicly available web-sources, also complemented with the data gathered through interviews.

The collected data was used in order to estimate the dynamics of interface implementation efforts,

which a mediation software vendor should be able to devote if it is to serve i) the incumbent operators and ii) the young operators. According to the data, a few dozens of the protocol types and over three hundreds of interface variations need to be supported if the software is offered to the incumbent operators.

Based on the available data, interface implementation efforts (in person-years) have been estimated for approximately 60% of the protocol types that are implemented by the mediation software vendor. Furthermore, we assume that this data obtained covers approximately 80% of the variations implemented by the mediation software vendor company. In order to compensate for the protocols/variations which were left outside of consideration, the resulting effort estimations were scaled accordingly.

The results of effort estimation are shown in Figure 2. In the graph, the efforts of interface implementation are shown for two cases:

- All types of interfaces are supported (dashed line).
- Only interfaces based on standard IETF protocols (RADIUS, LDAP, HTTP, SOAP, etc.) are supported (solid line).

The software vendors aiming at serving the incumbent operators need to implement all types of the interfaces; therefore, the efforts such a vendor needs to devote are considered in the first case (dashed line). On the other hand, the vendors serving new operators may have to implement only a (IETF) subset of the protocols, and therefore the corresponding efforts are considered in the second case (solid line). The total efforts in the first case were found to be 32 times greater than the efforts in the second case.

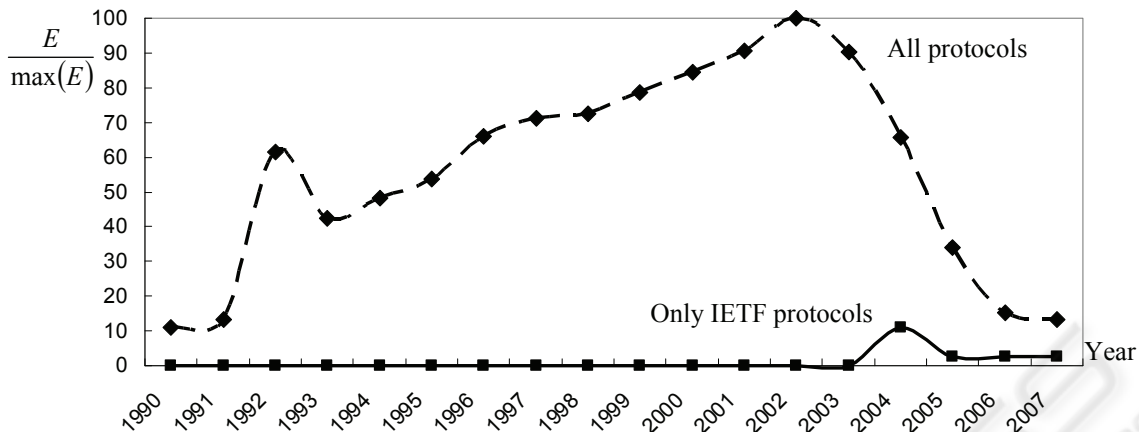


Figure 2: Efforts devoted to interface implementation by a mediation software company. In red: all types of interfaces are supported. In blue: only interfaces following IETF standards are supported.

The estimation of the interface implementation efforts can be used in order to estimate the size of the organization in both cases. Having assumed a specific portion of staff devoted to interface implementation efforts in the company’s R&D, the size of the R&D department(s) and consequently the total size of the organization can be estimated. Assuming that 5-10% of personnel are dealing with interface implementation and maintenance:

- In the first case, the organization is likely to have a few hundreds of employees.
- In the second case, the size of the organization is estimated to be a few dozens of employees (assuming that all protocols are to be developed within two years).

Therefore, only relatively big companies are capable of serving the incumbent operators, due to the large efforts required. Furthermore, since the current players have been implementing interfaces for many years and have accumulated a large “interface portfolio”, it is unlikely that a new player can compete with these players – the newcomer is unlikely to possess enough resources for implementing all (or a significant portion of) the interfaces.

On the other hand, it is much easier for new software vendors (especially those with highly limited resources) to serve the new operators which require only IETF interfaces to be implemented. As a result, a significant number of newcomers are likely to compete for the market of such new operators.

It is important to note that in the process of analyzing the mediation software interfaces, a

number of assumptions had to be made, such as the assumptions on the number of types of the interfaces and their variations, the assumption of the homogeneity of the interfaces across the operators of the same kind (i.e. incumbents and commencing), the assumption on the size of the R&D units in relation to the overall size of the software vendors, etc. Should some of the assumption be invalid, it may adversely affect the result of comparing the interface implementation efforts. Therefore, the conclusion on the likelihood of OSS/BSS market polarization should be considered with care.

4 BUSINESS IMPLICATIONS

4.1 General

In the paper, the efforts of software interface implementation and maintenance are considered as a factor influencing the structure of the software market. Higher interface implementation efforts play the role of a threshold for the vendors entering the market of incumbent operators thereby effectively disabling the entries by small commencing vendors (see also Figure 3 below). In a longer run, such a threshold can be assumed to reduce the number of software vendors in the market, causing a delay in the vertical disintegration of this market.

Furthermore, according to the results of the analysis, a market polarization scenario is likely whenever a fraction of the customers in the market require a large number of complex interfaces to be supported, while the other customers request only a small set of simpler interfaces. Therefore, a new

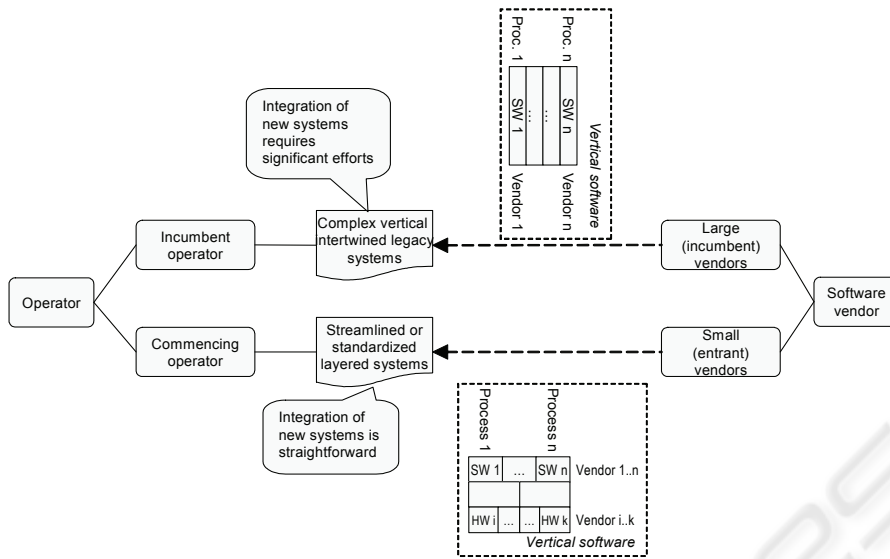


Figure 3: Incumbent operators are served by large software vendors, while the small vendors entering the OSS/BSS market will target commencing operators.

software vendor entering such polarized market may benefit from focusing on the submarket with the lighter interface implementation efforts. This is likely to increase the number of vendors in this new segment, thereby increasing competition which can be visible in form of wider variety of offering and price erosion. This chain of events is likely to benefit the new operators and lower the threshold for new operators to enter the market, which will increase the volume of the market segment.

4.2 Telecom OSS/BSS Software Market

In summary, the achieved results suggest that the co-existence of incumbent and new operators with distinct requirements for the interfaces to be implemented is likely to result in the co-existence of a few big and a large number of small software vendors serving these two types of operators.

The analysis points to a likelihood of niches in a software market, especially if the software is dependent of the use of specific hardware equipment as the physical networks of the operators. Software vendors that have long term partnerships with incumbent companies that are active in the industry (operators, software and hardware vendors) are likely to possess richer knowledge of their legacy technologies and systems, and these software vendors are likely to maintain their position in their segment of the market. However, this knowledge does not guarantee that they sustain their positions in the overall market: new solutions by new business

entrants starting with greenfield implementations may require another set of competencies, for example the ability to implement open source solutions as a service for the young operators. Furthermore, the competition comes not only from the the old timer telecom software vendors, but also from generic software providers.

5 CONCLUSIONS

According to industry evolution theories, a vertical software market gradually undergoes the process of vertical disintegration resulting in a set of horizontal software layers with standard interfaces, where the software at each layer can be provided by an independent software vendor. However, due to various reasons, the process of vertical disintegration may be delayed, and in extreme cases may never complete.

This paper suggests that the interfaces, which the software at one or few of the layers needs to provide may become an obstacle for the vertical disintegration. Because of the great efforts that may be needed for interface development and maintenance, only few big software vendors may be capable of competing in the market. As a result, the conditions necessary for vertical disintegration may never materialize.

The impact of interface implementation efforts on vertical disintegration has been studied in this paper in the case of the telecom OSS/BSS software. The results of analysing the efforts support the

hypothesis that, due to the co-existence of incumbent operators with highly complex interfaces and new telecom operators with relatively lightweight requirements for the interfaces to be implemented, the market of the OSS/BSS software is likely to be split into two polarized submarkets: the submarket of incumbent operators served by a few large software vendors, and the submarket of young operators served by a large number of small software vendors. As a result of the difference in the efforts, the submarket of young operators is likely to horizontalize, while the submarket of incumbent operators is likely to remain vertically integrated.

Besides prohibitively large interface implementation and maintenance efforts, the vertical disintegration of a software market may be hampered by other obstacles, such as the internal complexity of the business processes being automated by the software, the need to maintain compatibility with older systems, the need to comply with the legislation mandating the use of specific systems, etc. These factors, however, have been left out of the scope of this paper, and therefore further study is needed in order to address them.

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