FRAMEWORK FOR ANALYZING THE IMPLICATIONS OF ARCHITECTURAL SOLUTIONS TO MARKET STRUCTURES

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Keywords: Market structure, mash-up services, peer-to-peer, context distribution, value engineering.

Abstract: Understanding the economical effects of a technology has become more and more important. This has created a need for a conceptual framework to analyze the economic implications of technologies already in their design stage. So far, most of the research has been done in retrospect. Our framework is an organized approach to analyze this complex multidisciplinary task. The framework is experimented by analysing a case of a personalized mobile context-aware community web calendar. The market structure analysis concentrates on three solutions designed for the collection and distribution of user context and community information, an essential functionality for the service being developed.

1 INTRODUCTION

Understanding the economical effects of technologies is more and more important. Research done in this field has shown in retrospect that many chosen technologies have not been the most efficient or profitable ones. The problem is the lack of understanding the economic effects of a technology during its design phase. Also market competition has led into the use of current or outdated technology.

Understanding the economic effects already at the design stage is a complex task. The research in this area concentrates on the market effects of technology entries (Choi 1998), (Vega-Redondo 1996). Our approach tries to see the economic effects of the technological solutions under research and design. We experiment it in the case of a mobile context-aware web community calendar, and present and evaluate three solutions for the case.

2 CONCEPTS

Here we present the basic concepts of this paper.

2.1 Economics of Imperfect Competition

Economics of imperfect competition, better known as industrial organization, is a field of economics that studies companies' strategic behavior, market structure, and their interactions. It is also referred to as *industrial economics*. This paper deals with market structure and different strategic possibilities.

2.2 Enablers

In 2004, O'Reilly Media introduced the concept of *Web 2.0*; a new way of architecting software and businesses. It treats the web as a platform (O'Reilly 2005). It also encourages the users to contribute as service co-developers. Data from various sources is combined into *mash-up services*. An example mash-up service adds enriching information to an online map service, e.g. Google Maps.

Context information is any information that can be used to characterize an entity's situation (Dey 2000). Context-awareness is powerful for automatic service configuration in limited mobile environment.

3 FRAMEWORK STUDY

Table 1 presents the steps of our analysis framework. In the first step, *information gathering*, one defines the service requirements. In the second step, *benchmarking*, a market survey is carried out to build up a list of existing technologies and solutions to validate the service idea. In *criteria for evaluation*, one defines the criteria used to evaluate alternative solutions.

Kostamo N., Kassinen O., Koskela T. and Ylianttila M. (2007).
FRAMEWORK FOR ANALYZING THE IMPLICATIONS OF ARCHITECTURAL SOLUTIONS TO MARKET STRUCTURES.
In *Proceedings of the Second International Conference on e-Business*, pages 196-199
DOI: 10.5220/0002112101960199

Table 1: Description of steps in analysis framework.

Step	Task
Information gathering	Defining service requirements.
Benchmarking	Defining current markets and used technologies.
Criteria for evaluation	Defining the evaluation criteria and how they are measured.
Analyzing	The initial technical solution and market structure analysis.
Creation	Defining alternative ways to meet the defined requirements.
Evaluation	Selecting the best alternative based on the selected criteria.

Analyzing includes the analysis of the initial technical solution and market structure. In *creation* alternative solutions corresponding to the requirements are created. Finally, in *evaluation*, the alternative solutions are compared, and the best solution is selected.

3.1 Information Gathering and Benchmarking

Applying our framework to a problem case, we have to first define the service requirements (information gathering). The analysis of the current markets is not presented in this paper.

3.1.1 Context-Aware Mobile Community Calendar

As an example mash-up service scenario, we propose a *context-aware community calendar*. The existing commercial services, e.g., Google Calendar, work only if the users are members of the same community. Our calendar mash-up would share users' information while: 1) being independent of calendar type; 2) being independent of terminal type; 3) having private and public information; 4) having context-awareness if available; 5) not having all users from the same calendar-service provider. Next, we present the service architecture for the calendar.

3.1.2 Elements of the Service Architecture

User context, community and authentication related information can be collected, refined, and provided to web services by a mobile middleware component. The middleware may even apply group information from existing P2P communities to web services.

To ensure security, storage, and delivery of user information, it should be controlled by a trusted entity, which provides this information to authorized web services through a *control service*. Using the control service as a lightweight portal, the user may modify her community information and access the mash-ups (service discovery). Mash-ups consume user context and community information. Figure 1 shows the architecture.

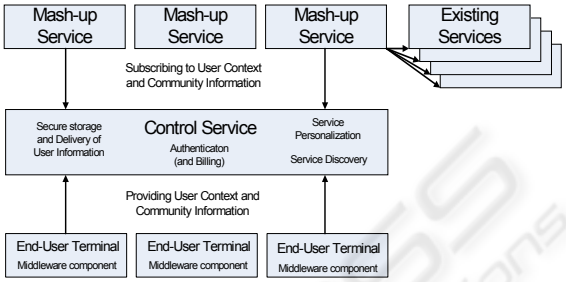

Figure 1: Elements of the service architecture.

3.2 Criteria for Evaluation

After the initial requirement analysis and benchmarking, criteria for the evaluation of the service are created and divided into two categories: (1) mobile device specific and (2) service architecture specific. The first one includes: terminal's processing power, terminal bandwidth, and metadata needs. The second one: control service load, centralized management need, system scalability, search efficiency (coverage/availability), information security, and standardization need.

3.3 Analyzing and Creation

In these phases different technical solutions and their market structure analysis are presented based on the previously defined requirements. We present three different solutions, *centralized*, *hybrid* and *peer-to-peer* (P2P), for implementing the delivery of user context and community information.

3.3.1 Technical Solutions

The first approach, management of data is fully centralized as seen in Figure 2 a). The mobile middleware would update the information to the control service (CS) at appropriate intervals and the mash-ups (MuS) could then access the user (peer, P) information. SP stands for superpeer.

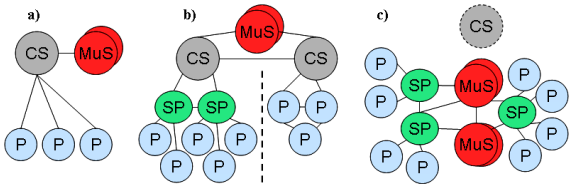

Figure 2: Technical solutions for context and community information delivery a) centralized, b) hybrid and c) P2P.

The hybrid solution utilizes the resources of decentralized P2P networks. The middleware could publish user information in them. Mash-ups query the network through the control service(s) that act as gateways to user information and bind together P2P networks of various providers; see Figure 2 b).

The third approach, seen in Figure 2 c), is organized completely in a P2P manner, the web servers also being part of the P2P networks. An instant messenger (IM) type client could operate as a service portal, launching the service directly to the browser, since service discovery and distributed rights control capabilities can be added to the client. The browser cannot locally manage the rights of user information, because they are scattered around the network. Service discovery queries could be made in P2P networks using the IM client, or service links could be passed on among users.

3.3.2 Market Analysis

As we can see from Figure 3, centralized architecture leads to an almost monopolistic market structure. However, an oligopoly is more likely; the service bundles offered by each retailer-lever company could be differentiated.

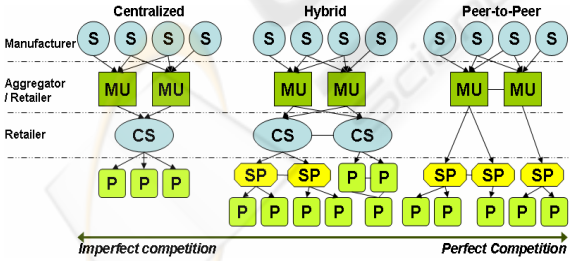

Figure 3: Market structures of proposed solutions.

Hybrid solution leads to monopolistic competition: there are many producers and many consumers in a given market. In addition, the consumers have clearly defined preferences, and the sellers attempt to differentiate their products from those of their competitors; the goods and services are still heterogeneous since the user group of each retailer differs from each other. The entry barriers of new retailers lie in attracting the users to your control service. Depending on the market share, the retailers do have some control over prices.

From Figure 3, we can see that P2P solution leads us closer to a perfect competition structure. We can see that the control service retailer-level is marginal as an authenticator. Information flow between Aggregator/Retailers and consumers is unrestricted as is necessary for the architecture to function well. All services from manufacturers could be available to everyone. This could lead to homogeneity or personalization of the service bundles.

All this said, we must remember that our study of these market structures is quite simplified. We do understand that in reality the perfect competition is a hypothetical market structure. To analyze the technology's effects to market structures better in the design phase, we would need more precise information on the market itself and, for example, competitor strategies.

3.4 Evaluation

In this final phase, we compare and evaluate the three distinct mobile community calendar solutions. Their technical features are compared in Table 2.

Table 2: Comparison of differences in technical features of proposed technological solutions.

	Central'd	Hybrid	P2P
Control service load	High	Medium	Low
System scalability	Low	Medium	High
Metadata need	Low	High	High
Terminal processing power need	Low	Low	Medium
Terminal bandwidth need	Medium	Medium	High
Information security	High	Medium	Medium
Search efficiency coverage/availability	High	Medium	Medium
Centralized management need	High	Low	Very low
Standardization need	Low	Medium	High

The *control service load* depends on the amount of context and community information being transferred through the control service; the load decreases when moving from centralized to P2P solution. It is quite obvious that *system scalability* is inversely proportional to the control service load.

The *metadata need* affects the terminal bandwidth need. The P2P solution needs more bandwidth

because the metadata includes the usage rights of the delivered context information. Furthermore, the *processing power* and *bandwidth needs* correlate with power consumption. Thus, the P2P model is the most demanding for the mobile device.

Information security and *search efficiency* are best handled by a trusted central actor. In context dependent services, search efficiency and data availability are critical, due to the dynamic nature of the data (e.g. location, presence). In P2P and hybrid solutions, efficient querying is achieved by dividing the load considering peers' capabilities. The peers with great processing power and bandwidth are set as *superpeers*, handling the message routing and the storage of user information (Gehlen 2005). Skype has proved a hierarchical P2P approach feasible for messaging and presence. Presence, which could also cover other context types, is delivered efficiently and securely in P2P manner; only the login server is centralized. (Baset and Schulzrinne 2004)

The *centralized management need* is the greatest in the centralized solution. The hybrid and P2P solutions allow the user to choose more freely his service and control service provider, and there is no urgent need for the operator even though it might maintain the P2P network and authentication services. However, the more different controllers, the greater is the *standardization need*, since interoperability of the players must be guaranteed.

Table 3: Differences in market structures.

	Central'd	Hybrid	P2P
Nr. of producers	Low	Medium	High
Network size	*n/m*	*n/m*	*n*
Type of services	Heterog.	Heterog.	Homog.
Service freedom	Low	Medium	High

Table 3 presents the main differences in the market structures. In centralized solution, the *number of producers* might be more than "low", but as in mobile operator markets, it is likely that the majority of the market share would be divided between 3 or 4 companies. The *network size of a company* is all the consumers using this kind of service (*n*) divided by the market share (*m*) of the company in question. In P2P, *n* is the number of consumers. The *type of services* is heterogeneous in the centralized and hybrid solutions and homogeneous in P2P, because of *service freedom* i.e. service selection available for consumer use.

Considering the three propositions, P2P might seem a good choice but its downsides are need for greater amount of metadata and processing power in mobile devices. Hybrid model, even though little restricted on service offerings, might be a good solution for mobile operator market implementation.

4 DISCUSSION

We have now presented a framework for analyzing the economic implications of technological solutions. We tested this framework for evaluating the information-distribution technologies for a community calendar service. Through utilizing this framework, we discovered three possible solutions for the delivery of user context and community information in this service. Finally, we analyzed the possible market structures of each solution and evaluated the differences between these alternatives.

More research is needed to understand the different economic implications of technology during its design phase. Also a study of co-existing technologies and solutions should be conducted.

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